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The Journal of Bone and Joint Surgery

PRESIDENT'S ADDRESS *

BY A. BRUCE GILL, M.D., PHILADELPHIA, PENNSYLVANIA

Let us pay tribute to those courageous men who organized The American Orthopaedic Association fifty-seven years ago. They and their followers laid solid foundations for modern orthopaedic surgery. They had to contend with the active opposition, the lofty superciliousness, or the reluctant tolerance of many members of the medical profession, as well as with the ignorance of the public. Could they be sitting in this distinguished audience today, how great would be their satisfaction and, possibly, their amazement as well, to see the tremendous development which has taken place in this field of medicine and surgery, and the recognized position of honor which it has attained. The brilliant light of modern orthopaedic surgery must not throw into obscurity the fundamental facts and principles of our science and art, which our predecessors labored so many years to establish and to make clear.

Our greater attainments are, naturally, a source of gratification, but they impose upon us larger duties and weightier responsibilities. Our services, as never before, are required by our Armed Forces and by our civilians at home. Those of you who are wearing the uniforms of our Country made your sacrifice unhesitatingly when the call came. Those who are left at home are working as never before and are carrying a double burden. The medical profession did not wait to be drafted for the War; it volunteered its services and began organization before the actual emergency arose.

Under the able leadership of the Surgeons General of our Armed Forces, our soldiers and sailors are receiving the best medical care in the history of the world.

As orthopaedic surgery grew in this country, it became necessary to organize a second national society, The American Academy of Orthopaedic Surgeons. There is no question of either one outshining or eclipsing the other. There is more than ample room for the activities of both. The yearly programs of each are filled with valuable papers that contribute new facts and new knowledge to scientific medicine. Many problems arise which require consideration and action by both societies, inasmuch as they affect the interests of orthopaedic surgery as a whole. Measures are even now being taken to promote interchange of ideas and facilitate joint action by these two organizations.

The scope of orthopaedic surgery today is tremendous. It is appalling to survey the literature of the past few years alone, and to note the vast number and variety of subjects that are presented for our study. None of us could presume to master all of them in a life-

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time. Some of them concern orthopaedic surgery alone; others share the interests of many specialties in medicine and surgery. It seems not improbable that various specialties will develop within orthopaedic surgery, as they have in general surgery.

Because of this vast increase in knowledge, the problem of education and training of orthopaedic surgeons has become more difficult. But nothing can be more important for the future of orthopaedic surgery than that men should be properly and wisely trained to enter its ranks. Education, although it continues throughout one's life, should be orderly. The proper foundation for it must be laid in the beginning. The student, during his undergraduate and graduate years of training, must master the basic principles of surgery in general, and of orthopaedic surgery in particular, before he progresses to the treatment of surgical conditions. He must learn all methods of treatment and the principles upon which they are based, before he becomes competent to select any particular method for any particular condition. He should be well-grounded in conservative treatment, before he learns to handle the scalpel. An orthopaedic operation is often only an interlude between long periods of conservative treatment. Operative surgery might well be called the flower of our art, and it can grow only from a sturdy tree that is firmly rooted in the ground. Because orthopaedic surgery is essentially the surgery of the mechanics of the body, the surgeon must master the science of body mechanics, before he should attempt to alter or improve the structure and the function of the members of the body.

There is some reason to believe that our younger orthopaedic surgeons are not sufficiently trained in these fundamental principles of surgery, before they are subjected to the enticements and the blandishments of the operating room. Too often, when they are called upon to treat a patient, their first thought is of some surgical operation, and too often they select some operative method which they learned in the hospital where they had their graduate training, because they are ignorant of other and possibly better methods to accomplish the purpose of the operation.

I believe that many of you agree with me that our methods of undergraduate and graduate training in orthopaedic surgery can be improved; that they should be subjected to a critical analysis; and that an attempt should be made to formulate a logical system of education. This Association, which includes in its membership many of the teachers of orthopaedic surgery in the Country, is peculiarly fitted for this undertaking. It already has a Committee on Graduate Training. With the approval of the Executive Committee, I have requested the members of this Committee to undertake a study of the problems of undergraduate as well as graduate education, and to formulate, as far as possible, a rational system of education and training. Their report might well be presented for consideration and discussion during one or more of our scientific sessions.

We should continue to give all possible aid to the joint Committee of The Association and The Academy on Inter-American Fellowships. I commend the members of this Committee, and, particularly its chairman, Dr. Oscar L. Miller, for the very valuable work which they have already accomplished.

The Journal of Bone and Joint Surgery continues to maintain the high standards established by its former Editor, Dr. E. G. Brackett, but our present Editor and his associates are considering plans to enlarge its scope, and to increase the number of its issues as soon as conditions become favorable. We may confidently expect *The Journal* to serve the needs of this progressive and expanding field of surgery.

I feel obliged to give some consideration to a subject that is of paramount importance to us, to the entire medical profession, and to the whole Country. I approach it with great diffidence and reluctance, but it cannot be ignored. It is difficult and complicated, inasmuch as it involves not only the entire system of the medical care of the people of the Country, but also the essential principles of the science of government and the determination of the form and technique of government which is best suited to the character of the American people. It concerns us as doctors to whom is entrusted the health of the people.

It concerns us as patriotic citizens upon whom the present and the future life and welfare of our Country depend. It must not be considered only in relation to the interests, selfish or unselfish, of individuals or groups and classes of people. It must not be determined only by motives of sound or unsound altruism, if it affects the welfare, the happiness, and the freedom of the Nation. Before this Country violates the principles upon which it was founded and in accordance with which it has grown, before it discards its traditions and enters upon vast and costly and possibly harmful experiments, it should think as clearly as possible and reason as best it can. The dual nature of the problem and some of the forces that demand its solution are clearly set forth in the following quotation from *The Philadelphia Inquirer:*

"A far-reaching proposal that would extend to workers and their families complete medical care was adopted by the International Labor Conference yesterday (May 11) at Temple University in Philadelphia. The Conference asks member governments to set up, as soon as possible, some form of medical care, either through a social insurance program or through a public medical care service, to exist side by side with private medical practice. The public medical service would be financed by taxation and the social insurance program by contributions of workers and employers, together with subsidies from public funds."

A bill which has been submitted to Congress embodies these ideas.

These proposals consist, really, of two propositions. The first is the promotion of public health and the improvement of medical care for the indigent and for individuals of average income. The second is that improved medical service or ideal medical care can be secured only, or best, by the intervention and the control in whole or in part by the Federal Government. There is no diversity of opinion as to the desirability of the first proposition. The medical profession has always labored wholeheartedly and unselfishly to improve public health and the medical care of all individuals in the Country and, for the most part, has originated measures to accomplish these ends. The second proposition is revolutionary and has given rise to differences of opinion. It is necessary to determine the essentials for adequate medical care, to note the agencies that have consistently and for many years been improving public health and medical service, and then to determine whether or not it is imperative or wise that the Country should adopt a system of governmental control of medicine to accelerate or to perfect medical services in the Country.

The quality and the extent of medical service for the people depend upon the sum total of medical knowledge, the education of doctors, and the distribution of medical science and skill to the people through the doctors of medicine.

Under the present system of medical practice, there has occurred a vast growth in medical knowledge; there has been a lengthened and more intensive education of doctors; and there has been a great increase in the number of those superlatively trained doctors who are specialists in the various fields of medicine and surgery. Medical research has been dependent, thus far, largely upon contributions from private wealth. If this should fail to meet the needs for the continued development of medical science, public funds should be appropriated for this purpose. The greatly increased expense of undergraduate and graduate medical training may eventually threaten the supply of doctors for the Country, and funds may have to be provided to enable young men and women of moderate means to engage in the study and practice of medicine.

The distribution of medical care has also vastly improved. Motor transportation, the establishment of well-equipped hospitals in many communities, many clinics conducted by charitable organizations and by public authority in numerous States have brought specialized medicine to millions of people. City hospitals with their clinics give to the indigent and to individuals of moderate means the highest type of modern medical service. The supervision of the health of children in our public schools; medical care afforded to workmen and their families by large corporations; the services of city, district, and state nurses, and the trained personnel engaged in public health work; hospitals built and maintained by the States for treatment and care of the crippled, the blind, the deaf and

dumb, the tuberculous, the feeble-minded; and contributions from public funds to community hospitals to provide care for the indigent may be cited from among the numerous agencies that have been devised to promote public health and to improve the medical care of the people. It is conceivable that existing agencies can be enlarged and extended, and new agencies added as necessary to render adequate medical service to all classes of the people and in all communities of the Country, without the intervention of the Federal Government.

The distribution of medicine depends essentially upon an adequate number of doctors and upon their facilities to practise good medicine, and to carry it to all the people. The supply of doctors is largely dependent upon the incentives which lead young men and women to enter upon the study and practice of medicine, and upon their financial ability to pay the expense of their education. The ambitious doctor will go where he can practise good medicine and where he can receive adequate financial compensation for his work. The facilities of hospital or group medicine attract the best men and bring to the community the highest type of medical service.

It is necessary, therefore, to scrutinize any plan for partial or complete direction or control of medicine by the Federal Government to determine, first, to what extent it would improve medical service for the people, second, whether this improvement could not be accomplished by other agencies, and, third (and most important of all considerations), whether it is consistent with our form of government and the character of the American people, and whether it is conducive or detrimental to the welfare of the Nation.

The Wagner-Murray-Dingle Bill or any similar bill, if passed by Congress, would by compulsory insurance and by general taxation provide vast sums to be expended by a department or bureau of the Government for medical purposes. Money could be appropriated for medical research. Is this necessary at the present time, and to what extent would it discourage contributions from private wealth? The Government could pay for the education of doctors, as it is doing during the present emergency. Would this produce better doctors? Does the removal of the necessity to work and to sacrifice to attain one's ambition make a better man of him? Would the opportunity for a free education be a worthy addition to the incentives which urge a young man to enter the noble but arduous profession of medicine; or, on the contrary, might it lead some men to study medicine when they have no particular interest in it?

Would the proposed plan produce a better distribution of medical care by increasing the facilities for it? The Government would employ the same doctors, the same hospitals, and the same agencies, community and state, that are now engaged in medical services. Would a change in the paymaster extend these services and stimulate better work? Fees and salaries would be established by the Government agency. How can it rate the value of medical services or the worth of one physician as compared with another? All proposed methods of payment by fee or by salary are open to serious objections. The doctors would become the servants of the Government, instead of the servants of the people. Is it not often true that Government employees lack the driving energy that is engendered by free competition? Physicians would receive fees for services to patients whom they now attend for nothing or for a minimal compensation. Would this secure better medical care for these patients? Admittedly, the Government could build and equip more hospitals, but the administration of a successful hospital and the quality of its medical staff are necessarily limited by the size of the population that is served by it. Extension of our hospital system could as well be accomplished by present agencies.

It is stated that many individuals in this Country are without adequate medical care. Who are they, where do they live, and why are they deprived of care under our present medical system? These are important questions that should be answered before we establish a new system that would provide services for 100,000,000 to 110,000,000 of our population. Is it assumed that this vast percentage of the people are without and are unable to secure the services of doctors and hospitals to minister to their needs?

These considerations and many others which I have not the time to mention cast grave doubt upon the ability of a Government-controlled system of medicine to improve medical care, and to promote public health beyond the ability of our present agencies so to do. The real purpose behind these proposals is identical with that which has within recent years prompted numerous changes in our system of government. Undoubtedly, there has occurred a marked increase in the power and authority of the Federal Government over the States and over the citizens, and this power has become concentrated more and more in the Executive or Administrative branch of the Government. We have been progressing toward paternalism and totalitarianism.

Government control of medicine would be another step in the same direction. Another vast bureau of Government would become established, with extensive powers over the lives of many millions of the people. These projects for what is called "social security" would be financed by compulsory insurance by the worker, by levies upon all who provide employment (and even upon the self-employed), and by appropriations from the general funds (all of which are forms of taxation). Under the provisions of the Wagner-Murray-Dingle Bill, $12,000,000,000 would be raised annually by these new taxes. This money would be placed in a Trust Fund that would be administered by a Board of Trustees composed of the Secretary of the Treasury, the Secretary of Labor, and the Chairman of the Social Security Board. Approximately one-fourth of the money would be assigned to a separate Medical Care and Hospitalization Account. The authority over the health and medical provisions of the bill would be vested in the Federal Security Administrator, the professional and administrative functions in the Surgeon General of the Public Health Service, and the administration of finances in the Social Security Board. Thus would be formed a powerful bureau, whose officers would be named or appointed by the President of the United States, and whose orders or edicts would become the law for the people.

Many eminent men have emphasized the dangers of bureaucracy and its government by executive orders, instead of by laws enacted by the representatives of the electorate, the threat of governmental paternalism to the initiative and forethought and self-reliance of the people, the peril to American Democracy occasioned by the rapidly increasing concentration of power in the hands of the Chief Executive, and the evils of excessive taxation which undermines the will to work and to save, and which in the end may ruin a nation and wreck a civilization. Taxation falls most heavily on those who work the hardest, who save the most, who display the greatest intelligence in the business of life. It can reach a point where it inevitably encounters the law of diminishing returns.

We should see clearly that a measure which poses as a plan to further the health and welfare of the Country may in reality be a threat to our birthright of freedom and the security of the Nation.

Do we desire our Government to protect us from foreign aggression and guard us from oppression within our own borders, to preserve our individual rights and our duties and responsibilities to our families and our neighbors? Or do we desire our Government to lift from our shoulders all fears and anxieties, to guard us from want, to provide for ourselves and our dependents in health and in sickness, in youth and in old age, to rob us of our manhood, and make us children indeed?

"And Esau said to Jacob, 'Feed me, I pray thee, with that same red pottage; for I am faint'. And Jacob said, 'Sell me this day thy birthright'. And Esau said, 'Behold I am at the point to die; and what profit shall this birthright do to me?' And Jacob said, 'Swear to me this day', and he sware unto him; and he sold his birthright unto Jacob. Then Jacob gave Esau bread and pottage of lentiles; and he did eat and drink, and rose up, and went his way; thus Esau despised his birthright."

And it is further written,

"Lest there be any . . . profane person, as Esau, who for one morsel of meat sold his birthright. For ye know how that afterward, when he would have inherited the blessing, he was rejected; for he found no place of repentance, though he sought it carefully with tears."

AMPUTATIONS *

BY COLONEL R. I. HARRIS, M.C., R.C.A.M.C.

Consulting Surgeon to the Director General of Medical Services of the Canadian Army

The time is opportune for us to assess our knowledge and practice of the surgery of amputations. For the second time in the lives of most of us, we find ourselves in the midst of war. As orthopaedic surgeons, we again face the surgical problems of war casualties, not the least of which are those associated with loss of the extremities. The last War gave us experience in amputation surgery, based upon large numbers of amputations handled as compact groups. It is well that at this time we should review that experience and summarize our knowledge, in order that we may more competently deal with the amputation problems which now face us.

One clear lesson arises from the experience of the last War. In dealing with amputations, it is of great advantage to segregate them in special centers as special orthopaedic problems. The three English-speaking countries in which we are most interested, Great Britain, the United States, and Canada, each evolved a plan for handling their amputation problems, the heart of which was the establishment of special centers to which patients with amputations were sent for treatment. Though the plans differed in other respects, in all these countries this one essential feature resulted in great improvement in the details of amputation surgery, great increase in our knowledge of amputation problems, and, especially important, a new fund of knowledge relating to prostheses and their suitability to various types of stumps.

Prior to this concentrated mass experience, the surgeon's knowledge of amputations was limited almost exclusively to the technical details of the operation, which he performed without much thought of how the stump which he fashioned would function when it was fitted with an artificial leg. The limb maker took the stump the surgeon gave him, and, as best as he could, fitted to it a prosthesis. There was virtually no opportunity for the limb maker to suggest to the surgeon that certain types of stumps functioned better than others; and, if there had been, it is doubtful whether the surgeon would have listened to him, feeling that a mere limb maker could not have anything to contribute to a surgical problem. The exigencies of war, which necessitated the handling of many amputations in special centers, and which placed the responsibility for their whole care upon the shoulders of surgeons, did more than anything in previous history to broaden and advance our knowledge of amputation surgery and prosthetic problems. All modern amputation surgery dates from the experience gained in handling the amputations of the last War.

PROBLEMS IN AMPUTATION SURGERY

The problems of amputation surgery are divided into two groups: (1) *problems related to the operation of producing the stump* (the exact technique of the operation, the length of the stump, the shape, size, and position of the flaps); (2) *problems related to the prosthesis* (its design, the principle on which it functions, the fitting of the prosthesis to the stump, and the maintenance of the stump in good condition). These two aspects of amputation surgery are intimately related, and cannot be separated one from the other. The amputation should be performed in such a manner that the resulting stump will function well. This necessitates knowledge of the available types of prostheses and of how they function. The prosthesis must be designed to make the most of the stump

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 3, 1944.

which is available. Finally, when the prosthesis is wedded to the stump, there must be clear knowledge of the troubles which may develop from this association, and of what measures may be taken to prevent or overcome them.

WAR AMPUTATIONS

In war, amputation surgery must be modified by the ever-present menace of infection. Wounds from shattering missiles, gross contamination with dirt, and the primitive conditions under which war surgery must often be conducted of necessity result in universal contamination in war wounds. Amputations resulting from war wounds must, therefore, be conducted in two stages:

1. *In the field*, the necessary amputation will be one of emergency, the sole purpose of which is to save the soldier's life. It will be performed for the removal of limbs which are irretrievably damaged, or of limbs so grossly infected that no other means of controlling the infection is of value. No more of the limb will be removed than is absolutely necessary to accomplish these objects, and the wound of operation will be so dealt with that infection will be controlled. At this stage, there will be no thought of the ultimate fitting of the stump to the prosthesis. The precision of operation and the perfection of healing necessary to produce a perfect functional stump are unattainable in the field. There we must be content to save the life of the soldier.

2. When the wound of the primary amputation in the field has healed completely, remodeling of the stump may be undertaken as a *secondary (late or definitive) amputation.*

The *principles governing the technique of amputations in the field* are: (1) save as much of the limb as possible to permit the widest possible scope for the subsequent definitive operation; (2) treat the wound by the standard principles established for dealing with war wounds,—débridement, removal of foreign bodies and dirt, open drainage, and chemotherapy; (3) when the infection has been controlled, manage the resulting stump with its open wound in such a manner (by traction or secondary suture) that healing will occur as quickly as possible, and with a minimum of deformity of the stump.

The application of these principles will vary slightly, depending upon the circumstances for which the amputation in the field is undertaken. Amputation will be necessitated by a variety of conditions. The most important are: (1) gross damage to the limb by the force of the missile or by crushing; (2) interference with the circulation of the limb by damage to major blood vessels, but without gross destruction to other structures (traumatic vasospasms, or gangrene from vascular injury due to bullets or shell fragments); and (3) virulent and rapidly spreading infections, especially anaerobic infections.

When extremely severe damage to the limb necessitates amputation, the bones usually are shattered. The skin is broken irregularly, and not necessarily at the same level as the fracture. To some degree, the level of the fracture determines the level of the amputation. It cannot be below the uppermost limits of the fracture; only occasionally will it be above it. Frequently the level of the skin damage is such that viable skin extends below the level of the bone section. Though the outline of the viable skin may be irregular, it should all be saved, unless there be much length of limb to spare. The resulting amputation will be of the open-flap type. Guillotine amputation should not be performed in this type of injury, unless there is great length of limb to spare. Utilization of all the skin remaining permits the saving of the greatest length of limb, and this will be well worth while, when later the definitive operation is performed.

If a limb requires amputation because of interference with its blood supply, due to section of the major vessels, there is usually a reasonably sharp line of demarcation between the living and the dead tissue. At this level or slightly above it, the limb should be removed by a modified guillotine amputation. Skin traction should be applied early to produce wound healing in the shortest possible period of time.

When the amputation is performed for spreading anaerobic infection, it must be a

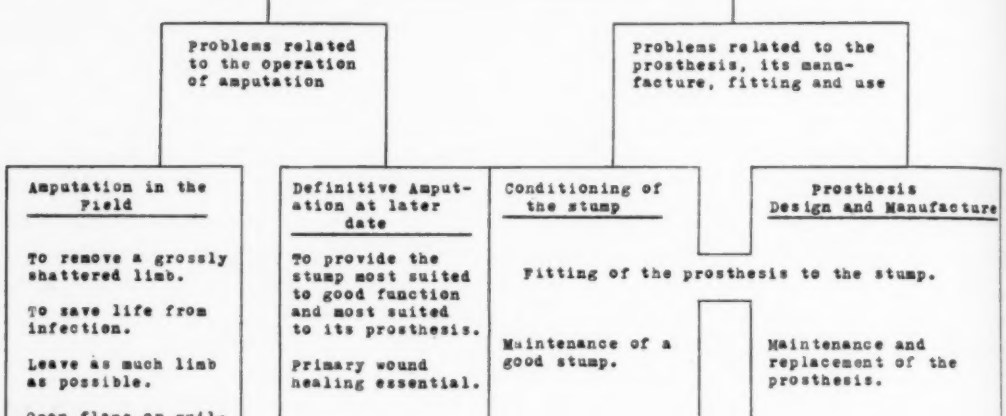
SURGERY OF WAR AMPUTATIONS
Problems related to the operation of amputation
Problems related to the prosthesis, its manufacture, fitting and use
Amputation in the Field
To remove a grossly shattered limb.
To save life from infection.
Leave as much limb as possible.
Open flaps or guillotine in type.
Delayed primary closure.
Definitive Amputation at later date
To provide the stump most suited to good function and most suited to its prosthesis.
Primary wound healing essential.
Conditioning of the stump
Fitting of the prosthesis to the stump.
Maintenance of a good stump.
Prosthesis Design and Manufacture
Maintenance and replacement of the prosthesis.
Field Surgical Units
Amputation Centre
Limb Factory

FIG. 1

A diagram illustrating the sequence of amputation problems in war, and the units in the Army and in Veterans Administration where such problems should be met. In the British and Canadian Armies, a Field Surgical Unit is a mobile operating team, capable of doing major surgery in advanced positions. Amputation Centers are organized in Canada only, not abroad; and the manufacture of limbs is in a Government-owned factory attached to an Amputation Center.

guillotine amputation, and at a level well above the limit of gross infection. Skin traction must *not* be applied until the infection is under control, but should be applied as soon as possible after that.

Open-flap operations can sometimes be closed at an early stage by delayed primary suture, and it is likely that this will become increasingly the case with the improved use of chemotherapeutic agents. Guillotine amputations cannot be closed by secondary suture. They must heal by granulation. To accomplish this with minimum delay and with the least sacrifice of bone, skin traction must be applied to the stump as soon as possible after the amputation, and must be maintained.

After healing of the wound of the amputation which has been performed in the field, the *secondary or definitive operation* can be undertaken. Since this is to provide as nearly perfect a stump as possible, primary healing is an important requisite. The operation should not be undertaken, therefore, until the wound of the first amputation has healed, and soundly healed. The necessity for a second operation is to provide a stump which will function well, when fitted with the best prosthesis available. The amputation which will be performed and the type of stump which will result are entirely dependent upon the type of prosthesis best suited for amputations at certain levels of the lower extremity. As there are four types of prostheses which have been proved by experience to be valuable, there are four standard amputations to correspond to them.

TYPES OF PERMANENT STUMPS AND THE PROSTHESES SUITED TO THEM

Under certain circumstances it is possible to produce an amputation stump which will be capable of bearing the whole weight of the body upon its distal end. This is true equally of the segment of the limb below the knee and of the segment of the limb above the knee. In each case, the level of transection of the bone must pass through its expanded

lower end, and the skin of the flap covering the end of the stump must be weight-bearing skin. The levels of these end-bearing stumps must, therefore, be: (1) just above the ankle joint, to be covered by the skin of the heel (Syme's amputation); and (2) just above the level of the knee, to be covered by the skin in front of the patella (Stokes-Gritti amputation). Both these end-bearing stumps are excellent. Properly fashioned, they will bear the body weight well, without distress to the patient, and without the development of secondary troubles, due to the artificial manner in which weight must be borne on any amputation stump. For both these stumps, excellent prostheses have been devised, which fit and function well.

If circumstances preclude amputation at the level of the Syme or the Stokes-Gritti stump, it is necessary to fashion a stump which will carry the weight of the body at its upper end,—below the knee, on the flaring condyles of the tibia; and above the knee, on the ischial tuberosity. Stumps, therefore, are divided into two classes: (1) those which bear weight upon the lower end; and (2) those which bear weight at or near the upper end. In the latter group, with which this paragraph is concerned, the length of the stump is of importance only for the purpose of motivating the artificial limb. Its useful length, therefore, is more or less constant.

From the foregoing, it is evident that there are four types of amputations of the lower extremity which are of value.

FIG. 2

A good Syme stump, seventeen years after amputation. (*From Memorandum on Amputations, N.R.C. No. 1218, National Research Council of Canada. By courtesy of Dr. A. B. LeMesurier.*)

Syme's Amputation

This is the most useful of all amputations of the lower extremity, because of the perfection of its weight-bearing qualities. The tibia and fibula are transected just above the level of the ankle joint. The lower fragments of these bones and the whole of the tarsus and metatarsus are removed, the heel flap being left to cover the ends of the tibia and fibula. It is the ideal operation, when amputation must be considered for destructive trauma of the forepart of the foot. It is so much superior to amputation through the calf that it should be performed wherever possible. To this end, the amputation in the field should save the heel, whenever possible, in order that Syme's amputation may be performed at a later date.

Such imperfections as do occur in the Syme stump are due to failure to secure primary healing, because of infection, or to misplacement of the heel flap. Primary healing of the heel flap obviously is essential to a good weight-bearing end on the stump, and every effort must be made to secure it. Syme's amputation should never be undertaken in the field, because of the risk of infection. For the same reason, it should not be undertaken as a secondary operation, until the wound of the first operation has healed.

A bad heel flap is one which is redundant, and hence is loose and wobbly, or one which is displaced to one side or the other or backward. These imperfections can be prevented by care in the modeling and management of the flap at the time of the operation. If they do occur, they can be corrected by a secondary operation which carefully remodels the flap.

Much of the success of a Syme amputation is dependent upon a good prosthesis.

FIG. 5
A good thigh stump.

FIG. 4
A good Stokes-Gritti stump, twenty-six years after amputation.

By courtesy of Dr. A. B. LeMesurier.)

FIG. 3
A good below-the-knee stump.

(From Memorandum on Amputations, N. R. C. No. 1218, National Research Council, Canada.

It must fit well, during both weight-bearing and walking; it must be strong enough to resist the strong leverage forces to which it is subjected, and it must not be too heavy. These qualities are obtained in the modern, well-designed Syme prosthesis by careful fitting and by the use of aluminum alloys. The prosthesis, however, is bulky, since it must enclose the bulbous stump. This bulkiness and the conspicuous lacing up the front make it aesthetically displeasing to women. Syme's amputation, therefore, is unsuited to women, because the prosthesis is conspicuous. To men this is of no moment, and the usefulness of the amputation outweighs all other considerations.

There has not been universal acceptance of the merits of Syme's amputation. Dr. Langdale-Kelham and Mr. Perkins at the great English limb-fitting center at Roehampton condemn it on the grounds that circulatory disturbances and ulceration develop in the end of the stump, and that weight-bearing is no more satisfactory than in the below-the-knee stump. Such has not been the experience of the Canadian Amputation Centers. A properly modeled Syme stump bears weight perfectly, and much better than any below-the-knee stump. In the Canadian centers, there has been no difficulty with late circulatory disturbances. Once a satisfactory Syme stump has been obtained, it remains satisfactory apparently for the rest of the man's life. It is just possible that the circulatory disturbances of which English surgeons complain are the result of climatic differences; perhaps they are related to such lesions as chilblains, which are common in England and almost unknown in Canada. Such shortcomings as we have found in Syme's amputation are due to technicalities related to the modeling of the stump. It is a more complicated operation than is a below-the-knee operation, but it still is within the competence of any good surgeon. It is true, also, that the injury which necessitates amputation may often not permit the saving of the heel flap and the performance of Syme's amputation. However, its merits are so great that, wherever possible, it should be performed as the operation of first choice.

Below-the-Knee Amputation

Most amputations below the knee must of necessity be at a higher level than the ankle, because of the situation of the injury. Such amputations will result in stumps which will bear weight at the upper end, on the flaring sides of the condyles of the tibia. The stump must be sufficiently long to move the artificial limb into which it fits, but it does not need to be longer. Indeed there are important contra-indications to making the stump of a below-the-knee amputation as long as possible. The necessity of bearing weight upon the diverging sides of the upper end of the tibia wedges the conical stump into the bucket of the artificial limb, and tends to choke the circulation. This can be accentuated by the necessity of lacing tightly about the thigh the leather corset which holds on the limb. Both these forces tend to obstruct the venous return of blood from the limb, and to cause swelling of the stump, and this in turn accentuates the circulatory disturbance. Short stumps are less prone to these difficulties than are long stumps. Consequently the stump which is sufficiently long to actuate the knee-joint mechanism of the artificial limb serves the purpose; there is no advantage and there are serious disadvantages in a longer stump. Since it is concerned with motivating the artificial limb and not with the size of the man, this ideal length of stump is approximately constant. Five and one-half to six inches, measured from the upper end of the tibia, is a good length for the stump; a longer stump gives rise to certain troubles; a shorter stump is less powerful, but is still useful. Amputation should be by equal flaps, either anterior and posterior or lateral; it makes little difference which. The stump in its final form should taper uniformly from base to apex.

The great majority of amputations below the level of the knee will be of this type, because the level of the injury will not permit a Syme amputation. If the stump is well modeled, it is a good amputation. There is voluntary control over knee-joint movements, and the gait is natural. Weight-bearing is not ideal. The sloping surfaces of the tibial

A good thigh stump.

A good Stokes-Gritti stump, twenty-six years after amputation.
(From Memorandum on Amputations, N. R. C. No. 1218, National Research Council, Canada. By courtesy of Dr. A. B. LeMesurier.)

A good below-the-knee stump.

condyles and the type of skin with which they are covered do not make perfect areas to take the body weight. In addition to the mechanical difficulties, lesions in the skin are apt to develop from occlusion of hair follicles and sebaceous glands, with infection behind the occlusion. Imperfect weight-bearing surfaces, the possibility of circulatory disturbances from choking of the stump, and the localized infections which occur in the skin limit the amount of activity which a patient can undertake upon a mid-calf amputation. For the most part, activities are restricted, and the more strenuous occupations are excluded.

A good prosthesis does much to minimize these shortcomings. A well-fitting bucket and a thigh corset, which fits smoothly and snugly over the full length of the thigh, will ensure the least trouble from weight-bearing and circulatory disturbances. The improvement developed at Roehampton, whereby some or even all of the weight of the body is borne upon the top of the specially reinforced thigh corset by the ischial tuberosity (tuber-bearing corset), may overcome many of the difficulties associated with below-the-knee stumps. Even though it is more cumbersome to use and to sit in, it may be the best form of prosthesis for difficult below-the-knee stumps.

Stokes-Gritti Amputation

The ideal stump below the knee is five and one-half to six inches in length, but stumps as short as two inches may be functionally useful and are valuable, since they retain voluntary control over movements of the knee joint. When it is necessary to perform an amputation higher than this, the Stokes-Gritti gives a useful stump; it is the amputation of choice, if the knee joint must be sacrificed and the patella is not greatly damaged. Other types of transcondylar end-bearing amputations may be of equal value. Our experience has been limited to the Stokes-Gritti amputation, and we can assert that a well-modeled Stokes-Gritti stump is most satisfactory. It easily bears all the body weight on its end; and troubles in the end of the stump do not develop. It is the best of all above-the-knee amputations, because of the excellence of its weight-bearing qualities. The number of occasions on which it can be used is limited by the few cases in which the injury is at the exact level which will make the amputation justifiable and feasible. If the knee joint is seriously damaged, a Stokes-Gritti amputation is probably impossible, and a mid-thigh amputation must be performed. If the injury is below the knee, a below-the-knee amputation, even with a short stump, should be attempted. It may function sufficiently well to justify retaining it, especially since it gives voluntary control of knee-joint movements. If its function does not come up to expectation, reamputation can always be performed. The occasions on which a Stokes-Gritti amputation can be performed then obviously are limited. However, within its field, it is a valuable amputation.

We have found the Stokes-Gritti a useful procedure with which to replace a poorly functioning below-the-knee stump. A short, badly scarred, below-the-knee stump, which bears weight poorly and in which a choked stump or skin lesions are constantly developing, can be a great handicap to its owner. If such troubles persist, it often is wise to replace the poorly functioning below-the-knee stump with a Stokes-Gritti. The freedom from stump trouble is more than enough compensation for the loss of voluntary control over the knee.

In performing the operation, the transection of the femur should be sufficiently high above the articular surface to permit the placement beneath it of the standard knee-joint mechanism (transverse spindle), without making the knee piece longer than the normal thigh. This level corresponds to one at which the cross section of the femur is approximately of the same area as the cut surface of the patella. Lower transection of the femur, while it broadens the area which bears weight, necessitates the use of a side-joint knee mechanism which is not very strong. The patella must be carefully placed upon the cut end of the femur and held there. The high section of the femur, already mentioned, fa-

cilitates this, since it prevents undue pull of the quadriceps. Solid fusion of the patella to the femur in good position is essential to good function.

To sum up, the advantages of the Stokes-Gritti amputation are its ability to bear weight on the end of the stump where it gives little trouble, instead of upon the ischial tuberosity where it may give trouble; and the simplicity of the prosthesis and the ease with which it is attached to the stump. It is the best of all above-the-knee amputations, and, in our experience, is not subject to circulatory disturbances.

Mid-Thigh Amputation

If injury necessitates amputation above the level of the knee, a mid-thigh amputation is best. As is the case below the knee, weight is borne either on the distal end of the stump (Stokes-Gritti) or upon the ischial tuberosity. If a Stokes-Gritti amputation cannot be performed, because of the level of the injury, the stump which is available will be of necessity an ischial-bearing stump. For this, a certain length of stump is necessary to motivate the prosthesis; a longer stump is not of essential value, and a shorter one will be made only of necessity. The ideal length is about eleven inches from the greater trochanter, but may vary a little, depending upon the size of the thigh and the height of the man. The flaps should be equal, and anterior and posterior, or lateral. Care must be taken to section the skin, fascia, and muscles at successively higher levels, and the femur at a level higher than any of the soft tissues. The stump should be conical, with no redundant soft tissues upon the end.

With this type of stump, weight is borne upon the ischial tuberosity. The artificial limb must be fitted with care to provide a broad edge on the rim of the bucket, on which the man sits. The stump must settle into the bucket, and must not ride up in a thick roll of soft tissues over the edge of the bucket. The skin needs care and cleansing to avoid the development of hair-follicle infections.

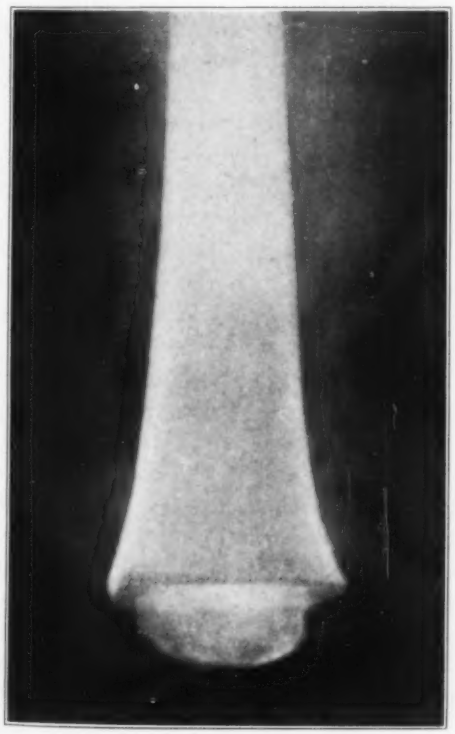

FIG. 6-A

FIG. 6-B

Anteroposterior and lateral roentgenograms of Stokes-Gritti stump.

In spite of the greatly abnormal manner in which a man with this type of amputation bears weight and walks, it is a surprisingly effective and reasonably comfortable combination of amputation and prosthesis. Few patients discard their artificial limbs and many manage to be active and on their feet most of the day. The gait is slower than normal, since extension of the knee is largely dependent upon gravity swinging the leg forward. Bad gaits often develop; these must be guarded against in training the man to walk.

RECONDITIONING

From an early moment following the primary amputation, attention must be directed to ensuring that the stump is in the best possible condition to motivate the prosthesis which ultimately will be applied to it. In the early stages, as soon as infection is under control, this attention should be directed to the avoidance of flexion deformity in the proximal joint and to the maintenance of muscle power by exercise. These activities should be continued throughout the period of healing of the wound of the primary amputation. When the definitive operation has been performed, or even sooner, there must be added exercises to familiarize the patient with the muscles he still possesses for motivating the stump. By section at the time of reamputation, these now have lost their normal insertion, and function differently than they used to. The patient must relearn to use them by careful, long-continued, and often-repeated exercise.

After the wound of the definitive operation has healed, steps must be taken to shrink the stump before fitting to it an artificial limb. The bulk of this shrinking can be obtained in the early stages by tight bandaging with crepe or elastic bandages. A great deal of the excess size and flabbiness of the stump is overcome by this means. The final shrinking will be attained only by the wearing of an artificial limb. It may be a temporary prosthesis, such as a peg leg; a provisional limb, such as the excellent fiber prosthesis provided for the American soldier; or the normal type of prosthesis, to be refitted when shrinking has been completed (This is the practice of the British). The peg leg has little to recommend it, save cheapness; it has the disadvantages of unnatural gait and unsightliness. It would seem much the best practice to achieve as much shrinking as possible and as quickly as possible by tight bandaging; and then to fit the stump at once with a provisional or permanent type of prosthesis, adding stump socks as shrinking continues; and finally to refit the limb when shrinking has finished.

THE ARMY AMPUTATION PROGRAM*

BY COLONEL LEONARD T. PETERSON, WASHINGTON, D. C.

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In order to promote the highest standards of amputation surgery in the Army, five General Hospitals were designated as Amputation Centers in March 1943. The Surgeon General has published information and directives relative to surgical principles, and has adopted a uniform system of prosthesis-fitting. The program is sufficiently flexible to permit local variations and the trial of new appliances, so that progressive improvement may result. This presentation concerns the policies of the program and a brief statistical summary, while, for the purposes of this symposium, the details of surgical procedures and prosthetic appliances will be discussed by others engaged in this work.

The open circular method of amputation was practised in the last War, and has been advocated since that time by military surgeons, as the procedure of choice in emergency amputations for trauma and infection. The principles may be summarized as consisting of amputation "at the lowest possible level which permits removal of all devitalized and contaminated tissue", and the immediate application of skin traction, which is to be continued until the stump heals. It is contemplated that secondary revision of the stump will be done later at one of the Amputation Centers, where the amputee will subsequently be fitted, and where he will be taught how to use the prosthesis, before he is discharged. In this study, 78.4 per cent. of the patients admitted to the Amputation Centers required secondary revision of the stump, which indicates the wide-spread use of the open type of amputation.

In May 1943, the Surgeon General called a conference in Washington, for the purpose of coordinating and standardizing the treatment and fitting of amputees. Provision was made at that time for the supply of artificial limbs and accessories which are supplied and fitted only at the Amputation Centers as follows:

Bushnell General Hospital, Brigham City, Utah;
Lawson General Hospital, Atlanta, Georgia;
McCloskey General Hospital, Temple, Texas;
Percy Jones General Hospital, Battle Creek, Michigan;
Walter Reed General Hospital, Washington, D. C.

All major amputation cases are transferred to the appropriate centers as soon as the patient can be transported with safety.

While the surgical principles of the emergency open amputation have long been established, it would seem appropriate to invite attention to three difficulties encountered during the early period of the present War:

1. *Closure of the Stump.* Although primary suture may be successful in emergency amputations in selected cases, failure is attended by such serious consequences that this procedure is contra-indicated in military surgery. Primary suture of a stump, where the amputation is due to trauma, requires sacrifice of stump length in order to avoid the site of injury and to effect skin closure. Primary suture is likely to result in cellulitis, osteomyelitis, or gas gangrene, which may endanger the patient's life, and may require additional sacrifice of the extremity. Infection in a closed wound requires prompt conversion to an open type of stump. The loss of stump length and the danger of infection may be avoided, if the amputation is performed at or immediately above the site of injury, and if the wound is left open. Viable skin should be preserved as far as possible, but long flaps which tend

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 3, 1944.

TABLE I

LOSS OF EXTREMITIES FROM BATTLE INJURIES FROM 1917 THROUGH 1918

No. of Extremities		No. of Patients	Per Cent.
Loss of one extremity		2,583	98.03
Loss of two extremities		52*	1.97
Both upper extremities	7		
Both lower extremities	34		
One upper and one lower extremity	11		
Total patients †		2,635	100.00

* There was no patient with loss of more than two extremities.

† Patients who had loss of only part of one or both hands or feet are not included in these figures; patients who had loss of part of one hand or foot, together with loss of one extremity, are included with those with loss of one extremity.

TABLE II

LEVEL OF AMPUTATION FROM BATTLE INJURIES FROM 1917 THROUGH 1918

Level of Amputations*	No. of Amputations	Per Cent.
Above or at the elbow	602	22.40
Below the elbow	278	10.35
Above or at the knee	1,282	47.71
Below the knee	525	19.54
Total amputations	2,687	100.00

* Patients with loss of part of the hand, 1,509, and loss of part of the foot, 292, are not included in this table.

to close the wound prematurely should be avoided. Infection is much more likely to develop after primary suture in the lower extremity than in the upper extremity.

2. *Open Amputation at a Higher Level than Necessary.* A few patients have been observed who had had a guillotine operation performed higher than necessary, sometimes through, or even above, the level of election for a finished stump. The emergency amputation should be as low as is consistent with a careful débridement; and the level of the bone lesion, rather than the skin wound or, in the case of chronic infection, the soft-tissue sinus, should determine the level of amputation, whenever the resulting stump is short.

3. *Lack of Skin Traction.* Early and continuous skin traction is an essential part of the open-amputation technique. Difficulties encountered in the evacuation of patients, as well as underestimation of the importance of traction, resulted in soft-tissue retraction in some patients. This simple but important problem has received considerable attention in publications of the Medical Department. Two measures that have been employed occasionally should not be considered acceptable substitutes for skin traction. One is treatment by a plaster cast, an excellent method of occlusive dressing and of immobilization, but one which does not prevent soft-tissue retraction; if the cast is desired, it should be used in conjunction with traction. The other is skin-grafting, which closes the wound, but permits retraction of skin and muscle, and thus prevents the desired closure by the normal skin. Skin grafts do not ordinarily withstand the pressure of a prosthesis, and are indicated only in special instances. Grafting may sometimes be desired before surgical revision, after the maximum benefit has been derived from traction. It should be noted that by far the majority of cases had excellent treatment, in accordance with the existing policies, and the difficulties mentioned have been corrected.

As soon as the amputation stump has been prepared by surgery and by physical

TABLE III

MAJOR AMPUTATIONS FROM JANUARY 1, 1943, TO MAY 1, 1944

No. of Extremities	No. of Patients	Per Cent.
Loss of one extremity	1,581	94.7
Loss of two extremities	89*	5.3
Total patients	1,670	100.00

* There was no patient with loss of more than two extremities.

TABLE IV

LEVEL OF AMPUTATION FROM JANUARY 1, 1943, TO MAY 1, 1944

Level of Amputation	No. of Amputations	Per Cent.
Above the elbow	215	12.22
Below the elbow	326	18.53
Above the knee	550	31.27
Below the knee	627	35.65
Syme's amputation	20	1.14
Chopart's amputation	13	.74
Hip-joint amputation	8	.45
Total amputations	1,759	100.00

therapy, it is fitted with an artificial limb. Each Amputation Center has a complete orthopaedic shop equipped for this work, and a close liaison is maintained between the surgeon, the limb mechanic, and the amputee. Patients with amputation of a lower extremity receive a provisional prosthesis, which permits adjustment or refitting as the stump requires. By the time the man is discharged from the Army, the stump usually has been stabilized, and this prosthesis continues to be used until a standard commercial limb is provided later through the Veterans' Administration. In the upper extremity, less change is likely to occur in the stump, and the artificial limb will be serviceable for a relatively longer period. Standard commercial parts are used, and a wide assortment of frames, hands, and hooks is provided, so that the individual may be fitted with the particular features that best meet his needs.

The history of the amputation service in World War I is especially interesting, in view of the similarity of the problems presented at this time. A brief statistical review of the loss of extremities from *battle* injuries in 1917 and 1918 has been compiled from the records of the Medical Department of the United States Army.[1,2] (The maximum strength of the Army in October 1918 was 3,567,856; the maximum strength of the American Expeditionary Forces in November 1918 was 1,910,854. The total admissions to hospital for battle injuries caused by missiles was 147,651. Admissions for fractures numbered 25,272.)

It can be observed in Table II that the amputations above the elbow exceeded those below the elbow, and that the amputations above the knee exceeded those below. The converse is true in available data from this War, probably an indication of greater conservatism and success in amputation surgery. On the other hand, approximately 2 per cent. of the patients underwent two major amputations then as compared to 5.3 per cent. in this War, suggesting that missiles and other agents today are more devastating.

In cooperation with the five Army Amputation Centers, statistics have been collected on all major amputations due to battle injuries *and other* causes, treated during the sixteen

months from January 1, 1943, to May 1, 1944. Since only a limited number of war casualties had been returned before January 1, 1943, and some of those still remained under treatment, this study includes practically all amputations incurred during the War, except those in patients awaiting evacuation from foreign theaters. It is estimated that approximately 25 per cent. of the total amputations in this survey resulted from training accidents, accidents not related to military activity, vascular diseases, and tumors.

It can be noted in Tables III and IV that one amputee in twenty lost two extremities; less than one in 200 suffered an amputation at the hip joint. Amputation is more frequent distal to, rather than proximal to, the elbow and knee, and the incidence in the lower extremity is more than twice that in the upper extremity. Few patients are injured at a level low enough to permit Syme's amputation, but this is performed whenever possible. Some patients with amputation through the tarsal bones have undergone a secondary Syme amputation, while others have elected to give the Chopart stump a trial.

The incidence of primary closure was not uniformly available in the total of 1,670 amputees tabulated in this study. However, in a group of 764 cases, sixty-eight (8.9 per cent.) were encountered in whom infection had followed primary closure of the stump. Since most of the patients in this group had been subjected to open amputation, the percentage of infection in all cases with primary closure was obviously much higher than this figure indicates. On admission, 361 patients (21.6 per cent.) were ready for prostheses, while 1,309 patients (78.4 per cent.) required surgery in order to make the stumps entirely satisfactory. Twelve hundred and nine secondary operations were performed during this period. Local complications after secondary surgery occurred in seventy-five (6.2 per cent.); most of these stumps healed after a slight delay, but a few required another operation. This is not considered excessive, in view of the fact that most revisions are done in the presence of a granulating area, and excision of scar tissue results in considerable bleeding. Infection or skin necrosis occurred in twenty-six and hematoma in forty-nine. With the increased use of penicillin, and utmost care in hemostasis, this figure may diminish. From January 1, 1943, to May 1, 1944, 1,074 prostheses were fitted.

The Army amputation program, in addition to problems of surgery and prosthesis-fitting, includes the morale and the training of the amputee. The patient with an amputation of the lower extremity is taught how to walk by the physical therapist, while the patient with an amputation of the upper extremity is trained in the use of the mechanical hook by the occupational therapist. Dancing classes, driving instructions, and other activities supplement the physical training and clinic activities. Individuals who have acquired special skill in the use of artificial limbs have visited the various Amputation Centers, and have contributed by training, developing morale, and offering practical suggestions on fitting and reeducation. The War Department has published recently a fifteen-page booklet entitled "Helpful Hints to Those Who Have Lost Limbs", which answers many of the perplexing questions common to the new amputee. A moving picture entitled "Meet McGonegal" shows the everyday life of a man wearing two mechanical hooks, after having lost both hands in World War I. Another moving picture is being produced which depicts the Army amputation program from the time of the evacuation of the patient to his rehabilitation. All these activities contribute a share in the reconstruction and rehabilitation of the war amputee.

REFERENCES

1. The Medical Department of the United States Army in the World War, Vol. XI, Surgery, Part 1, General Surgery, Orthopaedic Surgery, Neurosurgery, p. 72, War Department, 1927.
2. The Medical Department of the United States Army in the World War, Vol. XV, Statistics, Part 2, Medical and Casualty Statistics, pp. 15, 17, 1,017, and 1,019, War Department, 1925.

AMPUTATIONS: SURGERY AND PLASTIC REPAIR*

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The primary object in the treatment of an amputee is to obtain a well-shaped stump, covered with normal skin. It should be painless and should function well with a prosthesis.

There are many ways of attaining this end, and each case presents a different problem. Experience with a fairly large number of amputations during the War has taught us certain things that can be done, and certain things that definitely should be avoided, because they interfere with attainment of the object as stated. As in other branches of medicine, we learn more by our failures than by our successes.

The following facts have been learned from cases admitted to an Army Amputation Center.

The guillotine or open amputation has many advantages, especially under wartime conditions:

1. It is a simple débridement of the end of an extremity, which can be carried out quickly under adverse conditions.

FIG. 1-A

Guillotine amputation of the thigh. The protruding stump of the femur has been covered with skin grafts. Continued skin traction would have been preferable, and would have resulted in covering the stump with good skin.

FIG. 1-B

Showing stump after revision, removal of skin grafts, and closure without shortening of the stump of the femur. The entire stump is now covered with good skin and subcutaneous tissue which will not break down when a prosthesis is applied.

*Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 3, 1944.

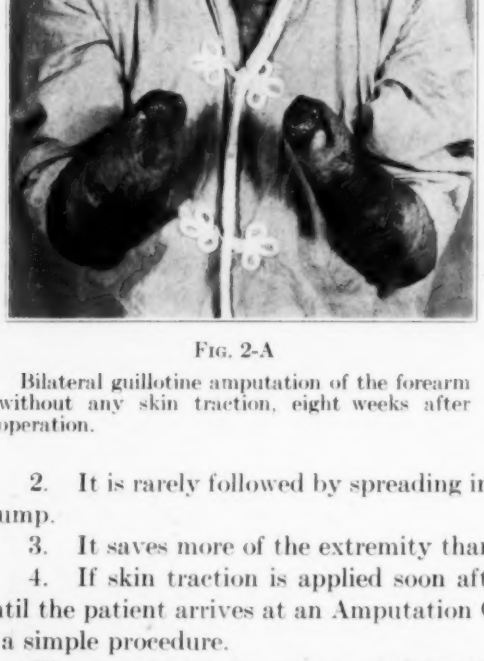


FIG. 2-A

Bilateral guillotine amputation of the forearm without any skin traction, eight weeks after operation.

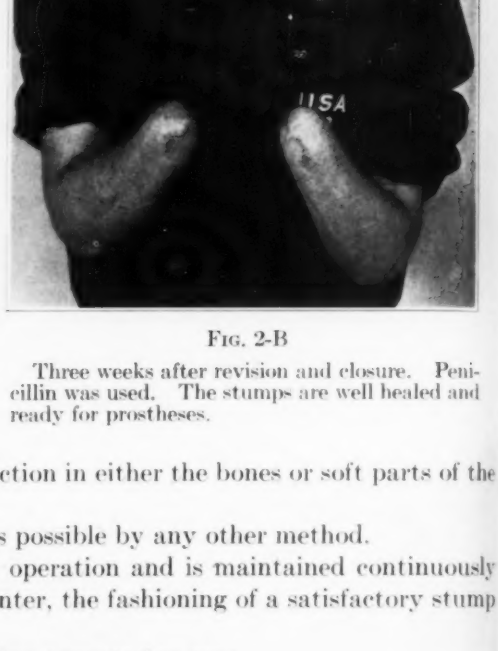


FIG. 2-B

Three weeks after revision and closure. Penicillin was used. The stumps are well healed and ready for prostheses.

2. It is rarely followed by spreading infection in either the bones or soft parts of the stump.

3. It saves more of the extremity than is possible by any other method.

4. If skin traction is applied soon after operation and is maintained continuously until the patient arrives at an Amputation Center, the fashioning of a satisfactory stump is a simple procedure.

The reasons for the success of the guillotine amputation are:

1. No devitalized material is left behind, in which infection will persist or spread.

2. The raw surface which is left exposed is not large, and it has a good blood supply.

3. If skin traction is constant, the healing process proceeds steadily, and the scar formation on the open end of the stump tends to pull all of the soft tissues over the end of the bone. In this process, the muscles and the deep fascia become adherent to the bone, and a firm, smooth, conical stump is formed.

4. The repair of such a stump is quite simple, as it is only necessary to excise the scar tissue and perhaps a small tip of the bone. The muscles and deep fascia are left attached to the bone, and flaps of normal skin and subcutaneous tissue are readily fashioned and closed without tension.

5. Stumps obtained by this method are as good as those achieved by primary amputations at the sites of election. They can be fitted with prostheses at an early date, as a large part of the atrophy and fibrosis that inevitably occur in the deeper tissues of a stump have already taken place. Even when the stump is too long and a reamputation is done instead of a revision, the postoperative healing is better and shrinkage of the stump is quicker than in a primary amputation at the site of election.

6. The frequent complications (in our experience in approximately 50 per cent. of the cases) which follow primary or early secondary closure are avoided.

In those cases in which a simple open amputation has been done at an early date at the site of the injury, and in which skin traction has been maintained continuously, the fashioning of a satisfactory stump is so easy that it can almost be considered a minor surgical procedure. It is only necessary to wait until the wound is clean and the oedema has disappeared, before carrying out the plastic closure or reamputation.

In a considerable number of cases, however, the creation of a satisfactory stump requires the best of surgical judgment and technique, as well as considerable patience on the part of both patient and surgeon.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Guillotine amputation of the thigh four weeks after operation. Skin traction has been applied constantly since operation. The open surface is clean and granulating.
Fig. 3-B: After two more weeks of skin traction.

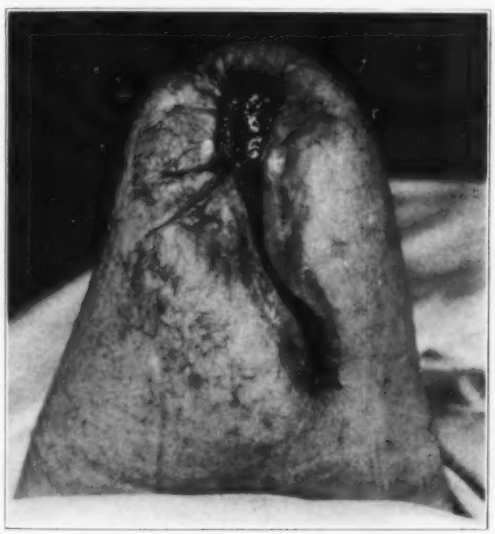


FIG. 3-C

FIG. 3-D

Fig. 3-C: Photograph taken two weeks after Fig. 3-B. Skin traction has been continued. Revision and closure were done at this stage.
Fig. 3-D: Photograph taken two weeks after revision and closure had been done without further shortening of the stump. Penicillin was used preoperatively and postoperatively.

Some of these cases are difficult and complicated, because of the nature of the original injury; examples of these are cases with vascular damage or severe soft-part injury. Others have been complicated by infection in the extremity above the site of amputation. Unfortunately some cases have been made more difficult by the primary treatment used, or by the failure to carry out the simple principles of the open amputation followed by skin traction.

If, in a severe compound fracture, an attempt is to be made to save the extremity, pin fixation should not be used above the site of injury. In several such cases, amputation has eventually been necessary at the level of the upper pin, whereas the worst result that should have been anticipated from such an injury would have been an amputation at the site of fracture.

Attempts to shape the bone ends or to outline flaps at the time of the original ampu-

tation frequently open up avenues for infection of the soft tissues, or result in sequestra at the ends of the bones. Early secondary closure often leads to the same unfavorable result, and may give a wide, adherent, painful scar.

Failure to use skin traction, or discontinuing it too soon, is by far the most common error in the treatment of open amputations. The healing process of an open amputation is necessarily slow. Constant traction allows the gradually contracting scar to pull all the tissues down over the exposed end of the bone. Removal of traction, or the application of a skin graft to the granulating area, immediately stops this process. The resulting stump will have the bone projecting beyond the level of the normal skin; and a skin graft, if used to cover the projecting bone, will inevitably break down and ulcerate, frequently even before a prosthesis is fitted. The plastic repair of such a stump requires extensive undermining of skin flaps and usually the sacrifice of considerable bone length. Although prompt healing of large surgical wounds, such as burns, by the early application of skin grafts is a recognized surgical procedure, it has been our experience that in no instance has a graft on a stump been tough enough to stand up under the use of a prosthesis, and, in every case except those where the stumps were too long, the application of a skin graft has made the revision operation more difficult.

In some cases, skin grafts have been taken from the sides of a stump in order to cover a clean granulating wound on the end. Such a procedure is contra-indicated, for eventually the stump will be fitted snugly into the socket of a prosthesis, where it will be subjected to more friction than the peeled sides or the grafted end can possibly bear.

The decision as to when a stump is ready for revision or reamputation is not an easy one. If the stump is already short, skin traction should be continued as long as the granulating area is healing. The type of organisms present in the open wound should always be determined, and the dressings should be varied accordingly. In most cases, sulfonamides are used preoperatively and postoperatively. It has been found possible to excise extensive scar and granulation tissue and even sequestra from a stump and to close the skin over the end, if the patient is given penicillin for twenty-four hours before, and fourteen days after operation. Frequently, however, the bacteria present in the stump are resistant to penicillin, and it is certainly safer, and usually preferable, to remove all sequestra and to control active infection before closure is attempted. Ordinarily a stump may be considered ready for revision when the general appearance, roentgenograms, and cultures show no active infection present, and when it is evident that normal skin can be closed over the end without tension or without shortening the bone unnecessarily.

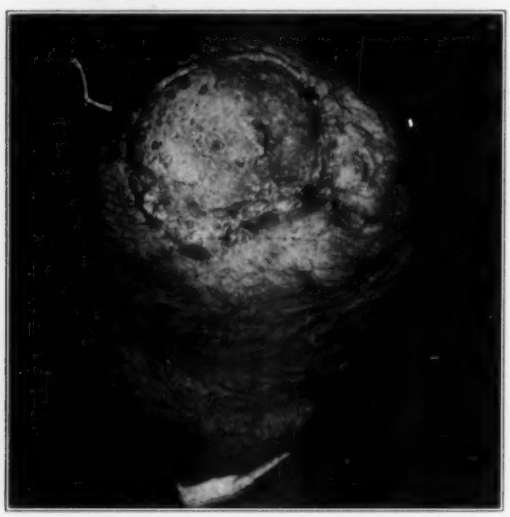


FIG. 4

Result of guillotine amputation of the thigh which had been followed later by the application of a skin graft to cover the unhealed stump end.

Surgical removal of the skin graft is always necessary. This method is far more difficult and the result less satisfactory than the continued use of traction and later closure of good skin over the stump end.

The actual operation is carefully planned to remove scar and granulation tissue, and just enough bone to allow closure of the skin and subcutaneous tissue without undue tension. The exact location of the final scar is of little importance, if primary healing is obtained. In order to secure smooth approximation of the skin margins without tension, it is usually advisable to undermine the skin flaps for a considerable distance. These flaps may be anterior and posterior,

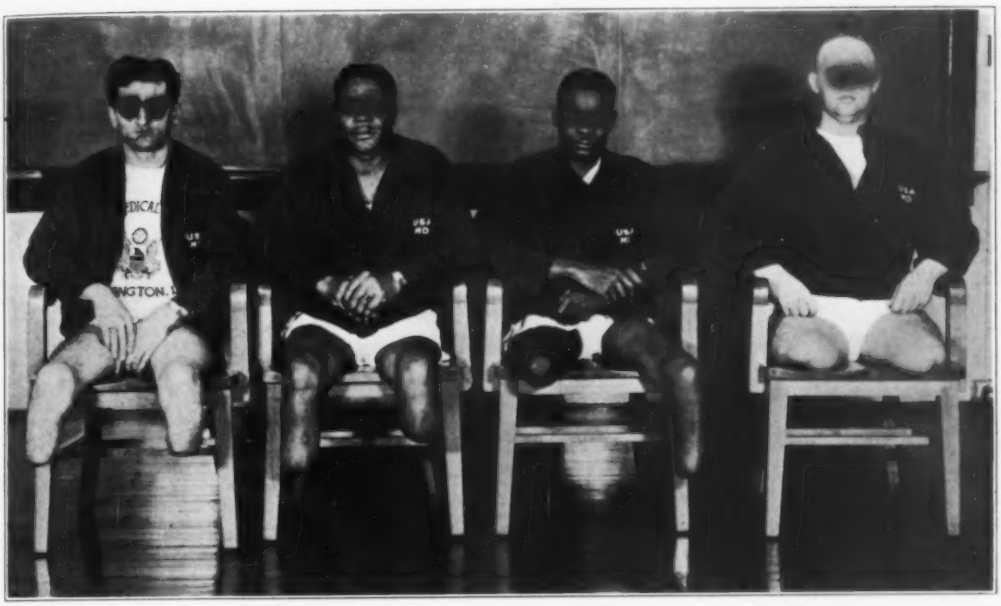


FIG. 5-A

A group of patients with bilateral amputation of the lower extremities, after revision operations had been done on the guillotined stumps.

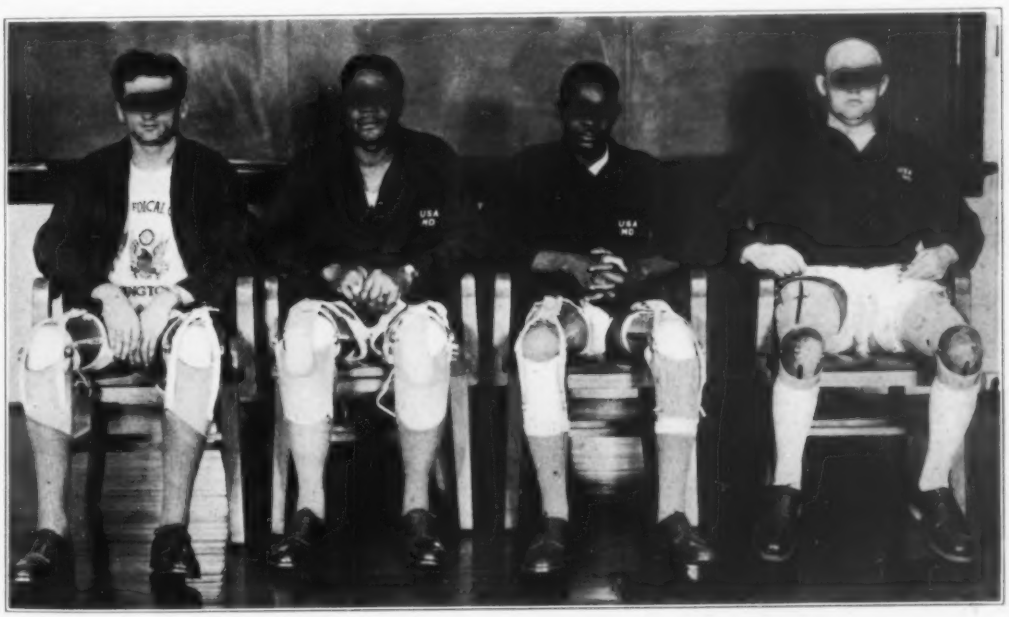


FIG. 5-B

The same group of patients after artificial limbs had been fitted.

medial and lateral, or one anterolateral and the other posteromedial. No subcutaneous sutures are used. Deep stay sutures are unnecessary, and often produce depressed transverse scars across the main scar. A rubber tissue drain near each end of the incision is used for one to three days, as it is almost impossible to secure a completely dry field. There is no danger of infection entering along the drain, provided the patient is protected by sulfonamide or penicillin therapy, whereas, a small pocket in the soft tissue, with a recurring hematoma, will often delay the complete healing of a stump for many weeks.

Postoperative skin traction is used, if there is any likelihood of tension on the suture line, due to postoperative swelling. This traction is especially indicated in the treatment of thigh stumps, as it provides immobilization and prevents flexion contracture of the hip. In a below-knee stump, a sugar-tong plaster splint gives excellent protection, and prevents flexion contracture of the knee. Gentle but continuous compression by an elastic bandage prevents swelling and hastens shrinkage.

Although some guillotine stumps heal so well that not even a scar excision is necessary before a prosthesis is fitted, plastic repair should be performed in most cases, in order to provide the best possible stump. It would be helpful if each amputee were advised at the time of the guillotine operation that every effort would be made to save as much of the extremity as possible, and, therefore, a second simple procedure would probably be necessary. Many of the amputees are totally unprepared for the revision of the stump; they are discouraged at the prospect of undergoing further surgery; and are bitterly disappointed to learn that they cannot immediately be fitted with prostheses.

In spite of the fact that a primary closed amputation at the site of election may seem to save surgeon and patient time and trouble, such a procedure, especially under wartime conditions, frequently results in a very unsatisfactory stump, because of bone or soft-part infection, bone spurs, painful scars, or neuromata. Early secondary closure also fails, in many instances, to give a satisfactory stump. Revision of such stumps requires thorough analysis of all the disturbing factors. Each must be corrected or eliminated by a carefully planned procedure, usually much more difficult than the simple plastic repair of a guillotine stump.

CONCLUSIONS

1. Under war conditions, the guillotine or open amputation, followed by continuous skin traction and plastic repair at a later date, is the most satisfactory way of treating cases requiring amputation.

2. Attempts to hasten healing of an amputation stump by skin-grafting should definitely be avoided, as the resulting stump is unfit for the use of a prosthesis and is much more difficult to revise than is one which has been allowed to heal under continuous traction.

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS IN THE ALIGNMENT AND FITTING OF AMPUTATION PROSTHESES FOR THE LOWER EXTREMITY*

BY ATHA THOMAS, M.D., F.A.C.S., DENVER, COLORADO

In the proper fitting and alignment of the amputation prosthesis, knowledge of the structure and function of the normal joints of the lower extremity, as well as of the relation of the joint axes to each other, is essential. Also of value is an understanding of the mechanics of normal locomotion and its relation to the pathomechanics of the gait with a prosthesis.

MECHANICS OF LOCOMOTION

Normal Locomotion

Human locomotion represents an intricate process of neuromuscular balance, which acts in accordance with certain well-known physical laws. Steindler describes the human gait as a constant alternating play between the two lower extremities, in which they alternately assume the function of support and propulsion (alternating bipedalism). Only one extremity at a time is used as a propelling force, whereas the other one swings forward. At the completion of the swing, the leg again touches the ground, first restraining the downward and forward tendency of the center of gravity, and then again assuming the rôle of a propeller of the body.

In normal walking, the supporting phase is longer than the swinging phase. Between the two swinging phases, there is a space of time in which both legs are in contact with the ground.

The forces which initiate and control locomotion are external and intrinsic. The external forces are gravity, normal counterpressure of the floor, and friction between foot and floor. Friction makes the underlying surface a firm point of application; without friction there would be no possibility of forward locomotion. (Note, for example, the difficulty of walking on a slippery surface.)

The intrinsic forces controlling locomotion are supplied by the muscles of the lower extremity, which act by extending the joints, propelling the body forward and upward. They also act by restraining the forward propulsion at the end of the swing.

The swinging phase is facilitated by the pendulum action of the limb under the influence of gravity, so that very little muscle action is necessary. The limb is flexed only sufficiently to prevent the toe from touching the ground. The importance of this pendulum action by gravity is emphasized in walking with a prosthesis.

The mechanics of walking, then, may be described as follows: Walking is initiated by inclining the trunk forward until the center of gravity has passed forward beyond the supporting base, bringing about a loss of balance. This is accompanied by a sudden extension of the joints of the supporting leg, propelling the body forward and slightly upward. At the same time, the opposite leg is lifted from the floor and swings forward in front of the supporting leg. At the completion of the swing, the leg again touches the floor in a partially flexed position, restraining the downward and forward tendency of the center of gravity. As the center of gravity moves forward over the supporting foot, the leg again is extended, generating the upward and forward propulsion of the body, and the cycle is repeated.[17]

It is quite proper, then, to describe the human gait as a constant play between loss and recovery of balance. As Oliver Wendell Holmes described it, "Walking is a perpetual

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 3, 1944.

falling with a perpetual self-recovery". An understanding of this interpretation of the human gait is of great value in teaching the amputee to walk properly with a prosthesis.

Pathomechanics of Gait with a Prosthesis

There are many factors that affect the efficiency and ease with which the amputee walks with his prosthesis. By far the most important are the alignment and fit of the artificial limb. Other factors are the site of amputation, the length and condition of the stump, muscle strength, mobility of adjacent joints, and, finally, the mental attitude, skill, and aptitude of the amputee.

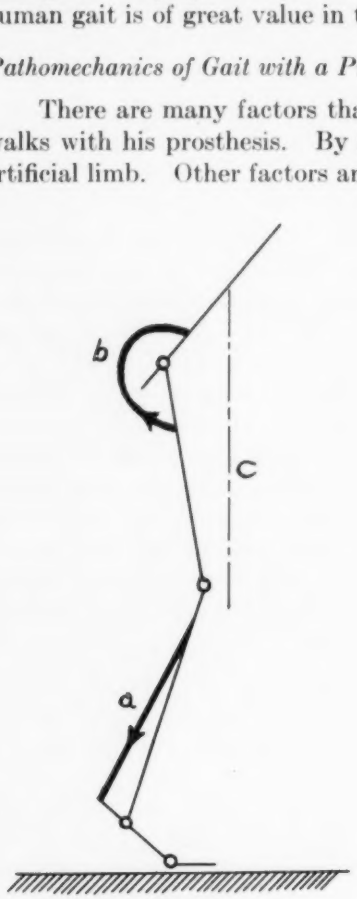


FIG. 1

Diagram illustrating how gravity, by action of the gastrocnemius and soleus (*a*) and gluteus (*b*) muscles, aids in knee extension in paralysis of the quadriceps. Knee-joint stability is maintained as long as the center of gravity (*c*) falls in front of the knee. (*Redrawn with changes and reproduced by permission of Arthur Steindler*[17] *and Charles C. Thomas.*)

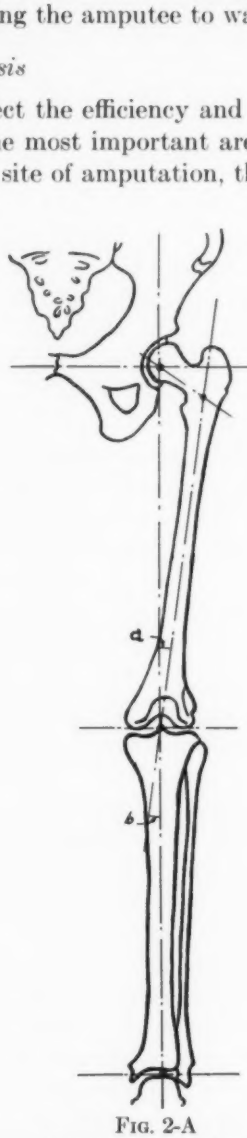


FIG. 2-A

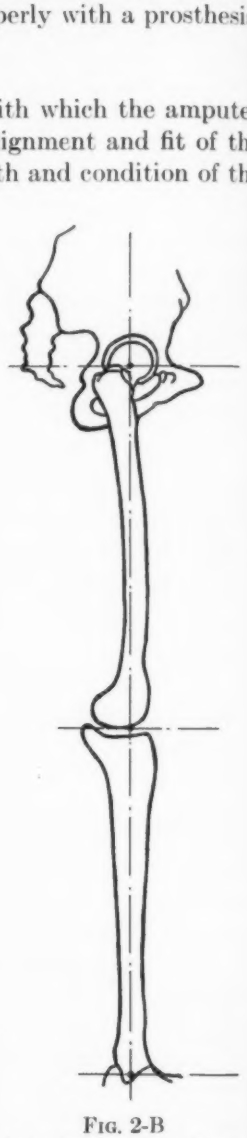


FIG. 2-B

Frontal and sagittal views of the bones of the lower extremity, showing the relation of the axes of the various segments.

In amputations below the knee, with a stump of sufficient length to give good leverage (five inches), there is remarkably little disturbance in gait. The function of the quadriceps muscle is undisturbed, and this muscle is the only one of importance in forward propulsion of the leg. Plantar flexion in the ankle is adequately provided for by elastic pressure through rubber cushions in the artificial foot. The amputee may experience some difficulty in walking on an uneven surface, because of the lack of lateral (subastragalar) motion in the foot. In the past, attempts have been made by limb makers to insert joints in the foot, allowing lateral motion; but, since these lack muscle control, they resulted only in instability.

Success in walking, with an amputation above the knee, is dependent largely upon stability and control of the artificial knee joint. Whereas most prostheses for above-the-knee

amputations are equipped with some type of artificial control device, such as elastic straps or inner springs, such controls are not essential for efficient walking. In fact, many amputees discard them entirely, after becoming proficient in walking with their prostheses. The pathomechanics of the gait with an above-the-knee prosthesis may properly be compared to that of the gait of an individual with a paralysis of the quadriceps muscle. This gait has been analyzed by Mayer (1914), who, according to Steindler, took issue with Duchenne's statement that the upright standing position is impossible with paralysis of the quadriceps. By following Mayer's analysis, it is easy to see that the paralyzed quadriceps may be compensated for by gravity without greatly interfering with standing and walking. By contracting the gluteus maximus, extending the thigh on the pelvis, and at the same time plantar-flexing the foot by contracting the gastrocnemius and soleus, the common center of gravity is made to fall in front of the knee joint, thus acting as an extensor (Fig. 1). Hence, upright standing is not only feasible, but is also fairly stable in cases of quadriceps paralysis, as long as the gastrocnemius, soleus, and the gluteal muscles are acting.[17]

In above-the-knee amputations with a direct stump-controlled prosthesis (pelvic suspension), a similar situation exists as in paralysis of the quadriceps. The gluteus maximus acts upon the stump and thigh piece of the prosthesis, extending the thigh. Although the calf muscles are absent, a substitute for their action is provided by placing the artificial foot in slight plantar flexion and maintaining it there, limiting dorsal flexion by regulating the thickness of the anterior rubber cushion (bumper) in the instep (Figs. 20-A, 20-B, and 20-C). Stability in the knee joint is further aided by placing the transverse axis of the artificial knee joint well posterior to the knee center. By careful adjustment and balance of these mechanisms and with proper instruction and practice, the amputee can learn to walk with agility and ease and yet with security, without the aid of any artificial device for controlling knee-joint extension.

Axes of Normal Joints as Related to the Artificial Joints of the Prosthesis

The finished prosthesis should conform as nearly as possible in appearance and function to the normal limb. In order that this may be accomplished, some knowledge of the position and axes of the normal joints is essential. At the upper end of the femur, the axis of the head and neck of the femur forms an angle of approximately 125 degrees with that of the shaft. As a result, the longitudinal axis of the shaft of the femur in the frontal plane is directed obliquely downward and inward, and does not coincide with the longitudinal axis of the tibia, but meets it at the knee joint, forming an acute angle (Fig. 2-A). In other words, there is an axial deviation of 10 to 12 degrees between the tibia and the femur.[17] On the other hand, the mechanical axis of the lower extremity as a whole coincides with the center of the hip, knee, and ankle joints (Fig. 2-A).

In the sagittal plane the femur curves slightly anteriorly as it passes downward (Fig. 2-B). At the proximal end of the femur, the greater trochanter and shaft are posterior to the head of the femur. The axis of the femoral neck is, therefore, directed forward and inward toward the center of the hip joint (Fig. 3, *B*). In other words, the shaft of the femur is rotated inward against the neck, and the neck and the head are rotated outward against the acetabular cavity, according to Steindler. Piersol states that this rotation averages about 25 degrees, but varies considerably in normal individuals.

The axis for flexion and extension of the hip joint does not coincide with the neck of the femur, nor does it run strictly in the frontal plane, but coincides with the central axis of the acetabular cavity which runs from forward and outward to backward and inward (Fig. 3, line *C*). This fact is often overlooked in the placing of the artificial hip joint in an above-knee prosthesis. The necessity of placing this joint well anterior to the greater trochanter in order to coincide with the true axis of the hip joint in flexion and extension is obvious (Fig. 3).

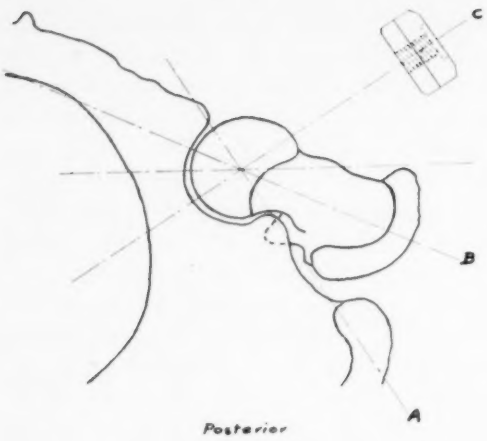


FIG. 3

Transverse section through the hip joint, showing the relation of the axis of the head and neck of the femur (*B*) to the central axis of the acetabulum (*C*). The true axis of the hip joint in flexion and extension does not coincide with line *B*, nor does it lie strictly in the frontal plane, but coincides with line *C* which is the central axis of the acetabulum. The hip joint of the prosthesis is placed so that its axis coincides with line *C*, the axis of flexion and extension of the hip.

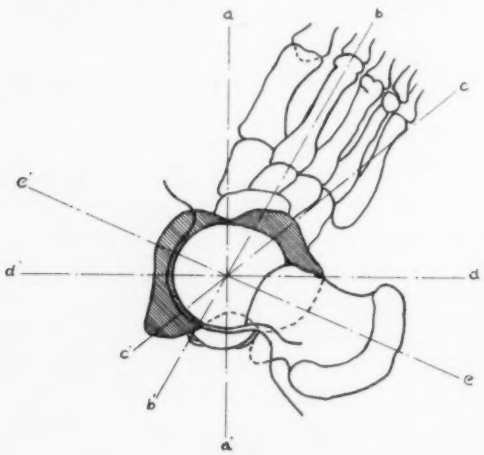


FIG. 5

Hip, knee, and ankle joints superimposed to show the relation of the axes of each joint to the others. The axis of the head and neck of the femur coincides with transverse axis of the ankle joint (*e'-e*), and is in external rotation to the axis of the knee joint in the frontal plane (*d'-d*). The central axis of the acetabulum (*c'-c*) is in internal rotation to the knee-joint axis (*d'-d*). *a'-a* indicates the sagittal plane of extremity; *b'-b*, the horizontal axis of the foot.

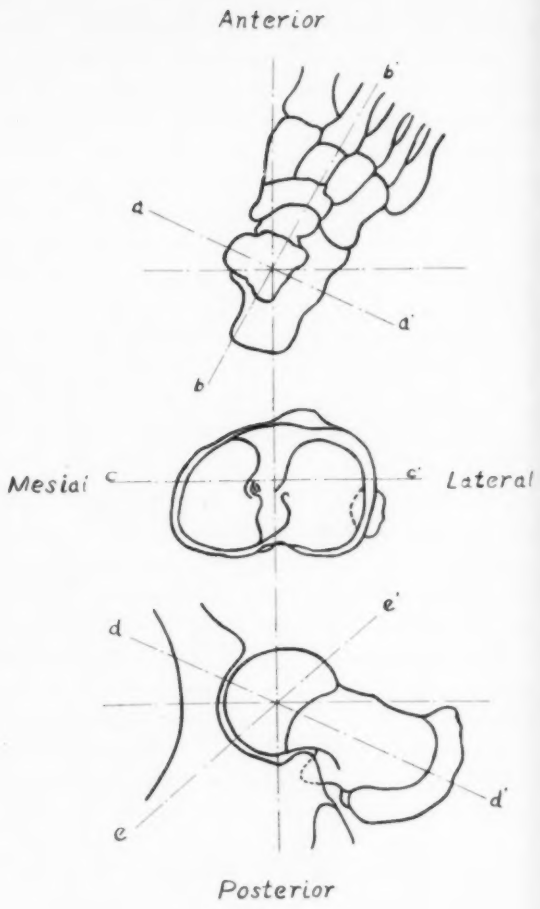


FIG. 4

Relation of axes of hip and ankle joints to knee joint. The knee-joint axis lies strictly in the frontal plane (*c-c'*), and the axis of the head and neck of the femur (*d-d'*) and the transverse axis of the ankle joint (*a-a'*) maintain a position of external rotation to the knee-joint axis. (*Redrawn with changes and reproduced by permission of Arthur Steindler*[17] *and Charles C. Thomas.*)

The transverse axis of the knee joint runs through the femoral condyles and lies strictly in the frontal plane (Fig. 4). The axis of the ankle joint, however, runs between the malleoli diagonally from outward and backward to forward and inward (Fig. 4). This is due to the outward twist of the tibia, causing the external malleolus to lie further posterior than the inner. Considering all three joints together (Fig. 5), therefore, the head and neck of the femur and the lower end of the tibia are rotated outward in relation to the knee joint.[17]

The knee joint is not a true hinge joint, but, because of the shape of the femoral condyles, the tibia glides posteriorly on the condyles as the knee is flexed. Such a motion obviously could not take place about one fixed center; but, as the knee is flexed, the axis moves posteriorly (Fig. 6). It is difficult to compensate for this gliding action in the artificial knee joint, but a fairly efficient compromise is obtained by placing the knee bolt

or side joints posterior to the knee center, or by the use of various types of polycentric joints.

In the foot and ankle, dorsiflexion and plantar flexion take place in the ankle joint,—the tibio-astragalar articulation. Lateral motion, on the other hand, takes place in the subastragalar joint, and to a lesser degree in the mid-tarsal joints. In the artificial foot, motion is limited in dorsal and plantar flexion, and no lateral motion is allowed. This is to insure stability (Fig. 7). As stated, attempts have been made by limb makers in the past to secure lateral motion by means of various devices. A most famous example of this was the Bly leg.* Such attempts have not proved very successful for reasons that are obvious. Since these devices all lack muscle control, instability results, just as it does in the paralytic foot following poliomyelitis. The action of the artificial foot of the amputee may well be compared with that of the paralytic foot stabilized by subastragalar arthrodesis.[9]

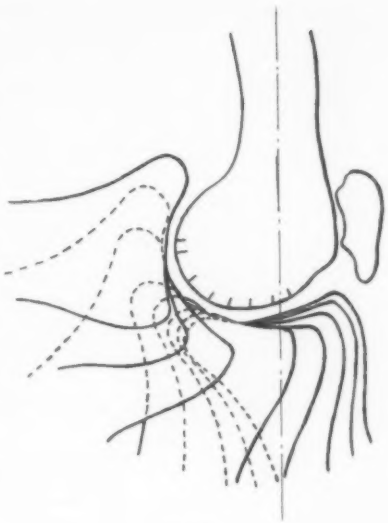


FIG. 6

This figure illustrates the gliding action of the tibia on the femoral condyles in flexion of the knee joint. The transverse axis of the knee joint is not a fixed point, but moves posteriorly as the knee is flexed. (*Redrawn with changes and reproduced by permission of Arthur Steindler* [17] *and Charles C. Thomas.*)

Motion at the metatarsophalangeal joints is essential for graceful walking, and in the artificial foot such action usually is obtained by a toe joint of rubber belting. It is of great importance that the axis of this "toe joint" correspond to that of the normal foot, which runs diagonally from the base of the great toe backward and outward across the foot (Fig. 8).

Because of the obliquity of the transverse axis of the ankle joint which runs between the two malleoli, the foot normally is rotated outward on the leg about 25 degrees (Fig. 5).

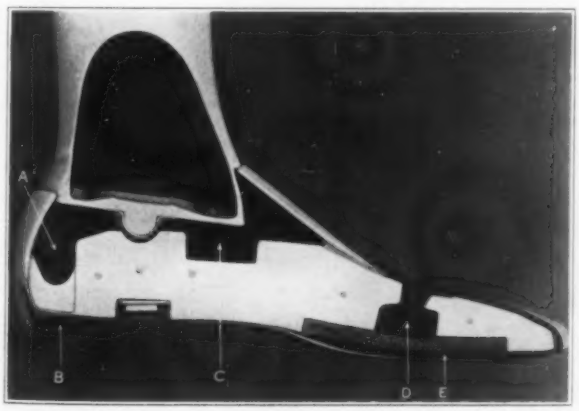


FIG. 7

Sectional view of conventional type of artificial foot, demonstrating position of rubber cushions, or bumpers, in heel (*A*), instep (*C*), and toe joint (*D*). These cushions permit limited motion in foot and ankle. The thickness and resiliency play an important part in the proper use of the prosthesis. Thin cushions of sponge rubber or felt are placed on the under surface of the heel (*B*) and sole (*E*) for additional resiliency and friction.

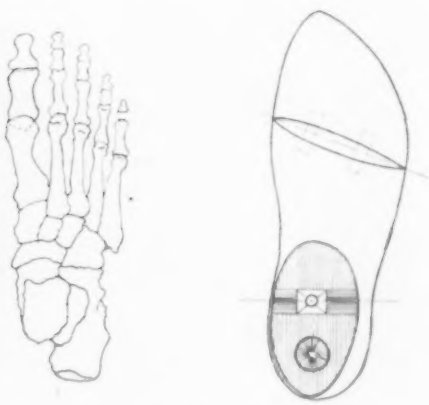


FIG. 8

The axis of the "toe joint" of the artificial foot should run diagonally from the inner side of the forefoot, backward and outward across the foot, to correspond to the axis of the metatarsophalangeal joints of the normal foot.

* Dr. Bly's anatomical leg, invented and patented by Douglas Bly, M.D., of Rochester, New York, in 1852, was claimed to have "embodied the principles of the natural leg in an artificial one by giving it lateral or side motion at the ankle".

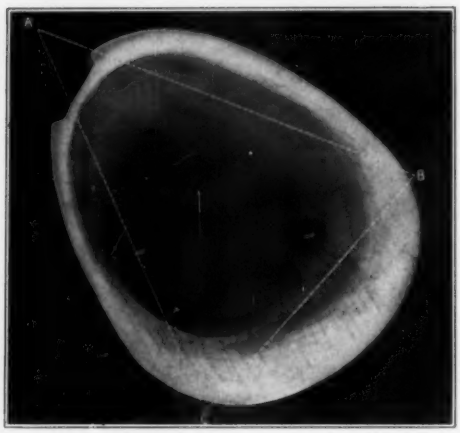
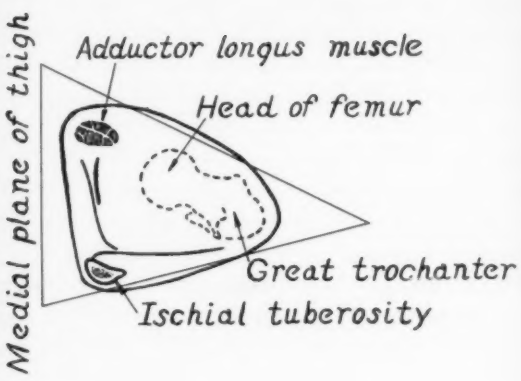


FIG. 9

View of thigh socket from above. The superior border of the thigh socket is roughly triangular in shape. The apex of the triangle (*A*) is lateral and anterior to the trochanter, and the base (*B-C*) is medial. Posteriorly and medially the rim widens to form the ischial seat (*C*) (left).



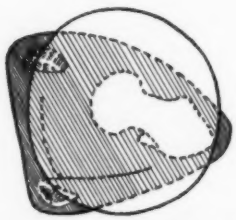


FIG. 10

These diagrams illustrate, with some exaggeration, the shape of the upper portion of the thigh stump (right). They demonstrate why the upper border of the thigh socket should be triangular in shape rather than round. (*Redrawn from "Artificial Limbs and Amputation Stumps"* [11], *and reproduced by permission of P. Blakiston's Son and Co.*)

FIG. 11

Thigh socket in the rough, illustrating that the shape of the socket conforms to the contour of the thigh. The socket is constructed separately, and then attached in proper alignment to the knee piece by dowels.

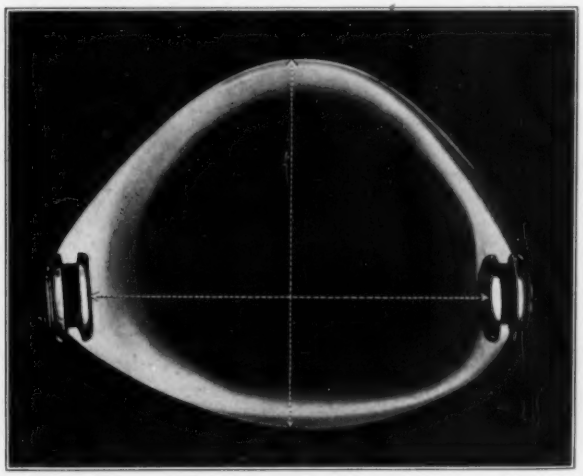


FIG. 12

View of the below-the-knee socket, from above, showing weight-bearing area and location of side joints. Weight is borne only on the anterior three-fourths of the circumference of the socket. The side joints are placed well posteriorly to the knee center.

In aligning the artificial foot on the shin piece, it is necessary that the same degree of rotation or "toe-out" be allowed as is present in the opposite foot. Failure to do this causes the prosthesis to rotate on the stump, producing abnormal friction and pressure.

It must be remembered that there is considerable variation in the configuration and axes of joints of normal individuals. In aligning the prosthesis, therefore, careful inspection and measurement of the opposite extremity is necessary, in order that the artificial limb may be made to conform as closely as possible to the normal. Florent Martin of Brussels, writing in 1924, emphasized that limb-fitting must be strictly individual, and that mass-production methods can never be very successful in the manufacture of artificial limbs.

PROSTHESIS FOR THE LOWER EXTREMITY

Component Parts of the Prosthesis

The compcnent parts of the conventional prosthesis for thigh amputations consist of the socket, the knee joint, the shin piece, and the foot. These parts are constructed separately and are then joined together in proper alignment. This alignment of the limb, which means the relation of the component parts to each other, is probably the most important single consideration in the manufacture of artificial limbs for the lower extremity.

The socket, or bucket, is that portion of the limb in which the stump is inserted and which bears the body weight. It is the most important part of the prosthesis, and must

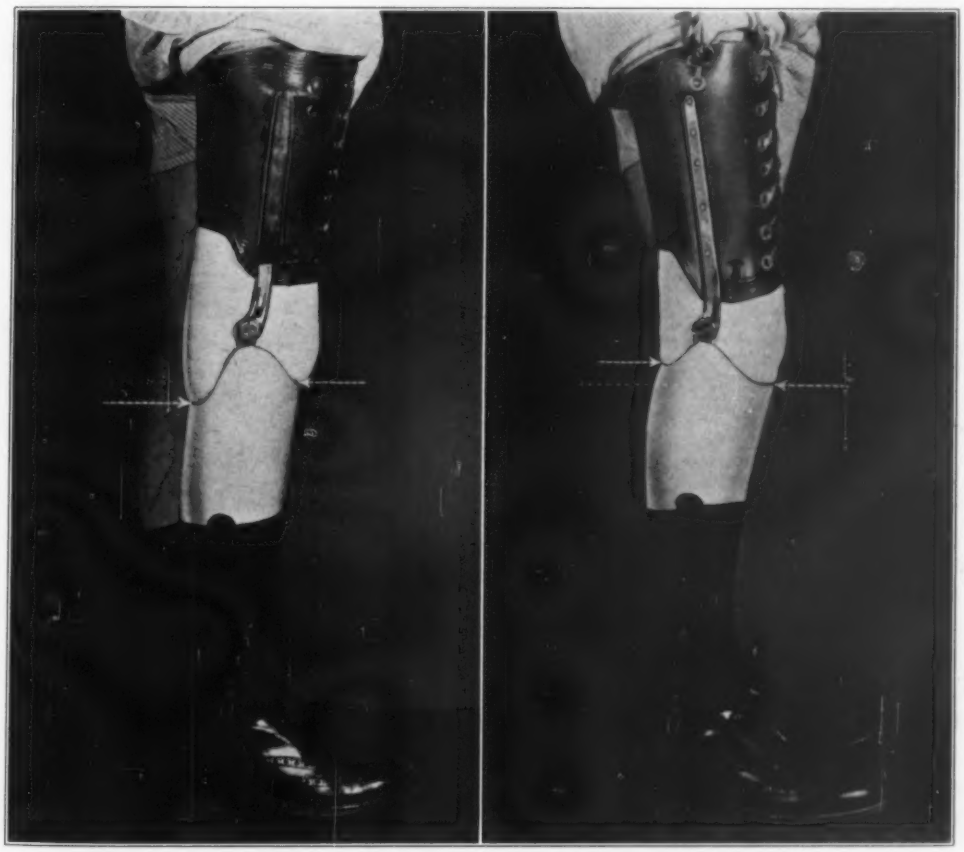


FIG. 13-A
Incorrect

FIG. 13-B
Correct

Side view of below-the-knee socket with knee extended.

Fig. 13-A: Posterior border of socket is cut too low, allowing bulging of soft tissues of the popliteal area.

Fig. 13-B: Correct height of the posterior border of the socket extends to the same level as the anterior border or higher.

be shaped and fitted accurately in order to bear weight comfortably and not interfere with the circulation of the stump. The socket is constructed, so that its bearing surface corresponds as nearly as possible with those areas of the body that normally are subject to weight-bearing. Such areas are the ischial tuberosity, the front of the leg at and just below the knee, and the heel. The articular surfaces of joints and the bone adjacent thereto also are well adapted to weight-bearing. Such bone is of the finely trabeculated cancellous type, with thin cortex, and covered by thin adherent periosteum or articular cartilage. Tubular bone, on the other hand, with its heavy cortex and open medullary canal, does not tolerate weight-bearing well. The tendinous origins and insertions of muscle withstand pressure well, but the bellies of muscles are normally subject to little pressure and will not tolerate much weight-bearing in the amputation stump. In normal weight-bearing surfaces of the body, the fascia is adherent, not gliding, and there is a minimum of areolar tissue. The skin over such areas is thicker, sebaceous glands are scarce, and sudoriferous glands are more plentiful.

The socket for the thigh-amputation prosthesis is always fitted with ischial weight-bearing, although some weight is taken on the lateral surface of the thigh and on the greater trochanter. No weight is borne on the end of the stump, except in amputations at or just above the knee joint. It is also necessary that pressure be avoided in the adductor region on the inner side of the thigh. Ample room must be provided for the adductor tendons by shaping a channel at the junction of the anterior and medial sides of the socket. Great care should be exercised to bring the medial side of the socket well up

FIG. 14-A
Incorrect

FIG. 14-B
Correct

Posterior view of below-the-knee socket with stump in place.
Fig. 14-A: Posterior rim is cut too low.
Fig. 14-B: Posterior rim of socket is of correct height.

into the perineum, making sure that the flesh in this area does not roll up and protrude over the top of the socket.

The thigh socket is not round but is roughly triangular in shape (Figs. 9 and 10). The apex of the triangle points outward over the trochanter, the base is medial, extending from the origin of the adductor muscles to the ischial tuberosity posteriorly. As the medial border approaches the tuberosity, it widens out to form the ischial seat. Hendrix has compared the ischial seat of the prosthesis to the saddle of a bicycle, split lengthwise in half, whereby the ischial tuberosity rests on the wide posterior part of the seat, and the inferior pubic ramus fits over the anterior narrow prolongation of the seat.

As the socket extends downward, it is shaped to conform to the normal anterior bowing and medial inclination of the femoral shaft. In thigh amputations, the stump usually is held in some flexion, and the socket must be shaped inside to conform to this flexed position. A marked flexion deformity, however, makes alignment and fitting difficult.

The socket is shaped and fitted to the stump as a separate unit and then is fastened by dowels to the knee block in proper alignment (Fig. 11). Any adjustment necessary to change rotation or to re-align the limb in any way can be accomplished only by detaching the socket from the knee piece and making the necessary correction in the relation of the two segments. As pointed out by Kirk, the socket fits the stump in one position only, and changes in alignment cannot be made by shifting the socket on the stump.

The socket for amputations below the knee requires more skill in fitting than any other. Because of the irregular surface of the weight-bearing areas below the knee and the presence of certain areas in this region that will not tolerate any pressure whatever, this socket must be very skillfully and accurately fitted, if it is to be worn successfully. The opinion is held by some that the below-the-knee stump will not tolerate weight-bearing over a long period of time. That this belief is erroneous has been proved by the experience

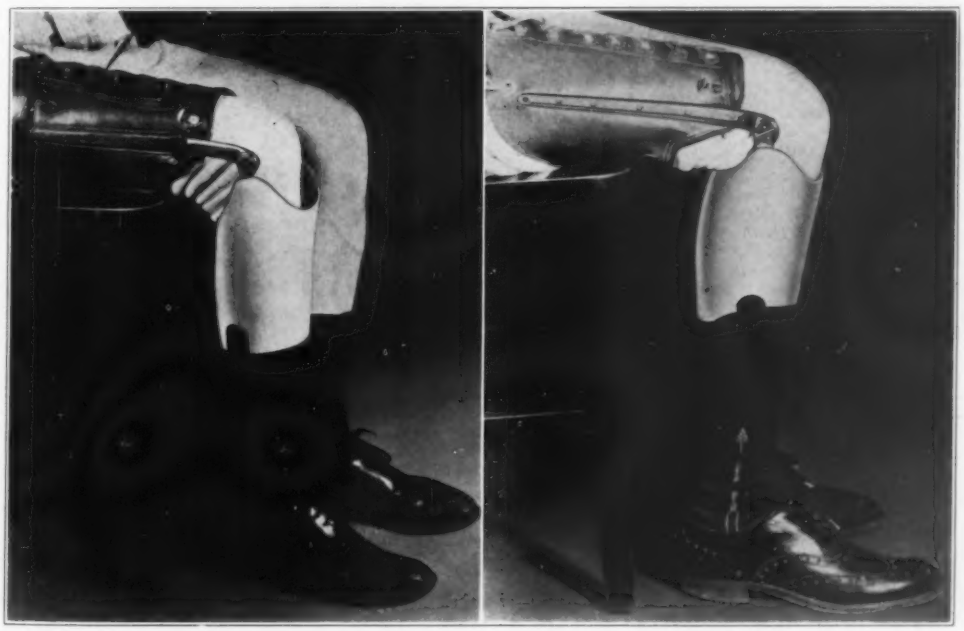


FIG. 15-A
Incorrect

FIG. 15-B
Correct

Side view of below-the-knee socket with knee flexed.

Fig. 15-A: The side joints are improperly placed, and the posterior rim of the socket is cut too low, causing the stump to displace posteriorly, with bulging and pressure in the popliteal area.

Fig. 15-B: The side joints are correctly placed posterior to the knee center, allowing the socket to extend well up into the popliteal space when the knee is flexed.

of the limb makers of this Country who each year successfully fit thousands of below-the-knee stumps with full weight-bearing below the knee. In their experience, it is rarely necessary to fit a good below-the-knee stump with full or even partial ischial weight-bearing. Where the stump is not ideal, such additional support may be necessary, but this is much better than sacrificing the knee joint.

The principal points of weight-bearing on the below-the-knee stump are the tibial condyles, the tibial tubercle, and the head of the fibula. These all lie at the same level and form the base of weight-bearing. This base forms the anterior three-fourths of the circumference of the stump (Fig. 12). The posterior one-fourth, formed by the popliteal space, will tolerate no pressure. Most of the difficulties observed in below-the-knee stumps are caused by pressure in the popliteal space. This pressure interferes with circulation resulting in oedema and swelling, and eventually in ulceration of the stump.

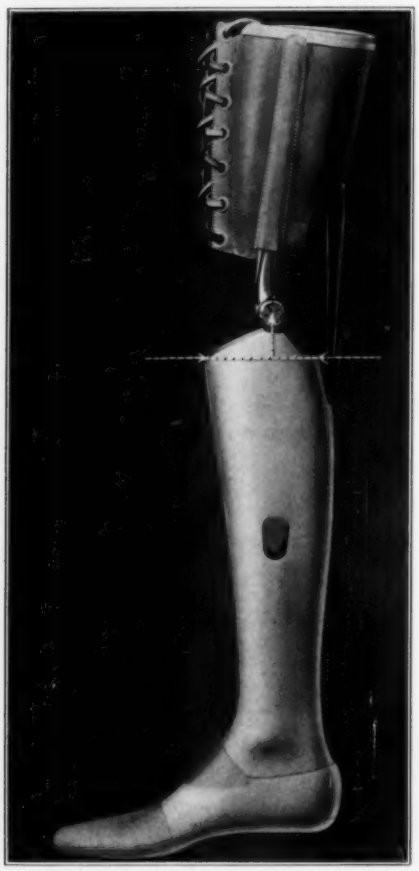


FIG. 16

Side view of below-the-knee prosthesis, illustrating proper position of the side joints and correct height of the anterior and posterior borders of the socket.

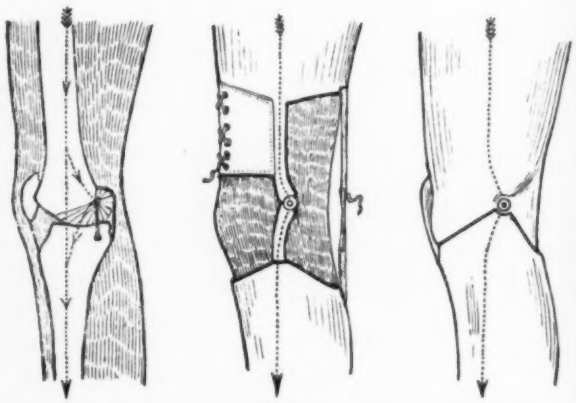


FIG. 17-A FIG. 17-B FIG. 17-C

Bigg's original diagram illustrating the importance of placing the knee-joint axis of the prosthesis well posteriorly.

Figure 17-A "is a diagram, explaining the self-locking mechanism of the natural human knee joint and it shows the position of the axis of motion posterior to the line of weight, inducing over-extension".

Figures 17-B and 17-C "show respectively the same principles carried out in the knee joints of an artificial leg for amputation below the knee, and one for amputation above the knee". (*Reproduced from "Artificial Limbs and Amputations."*[1])

The stump should fit into the socket snugly but not tightly, and a certain amount of up-and-down motion or "piston action" is necessary. A common practice among limb makers is to shape the socket, so that the stump fits into it in slight flexion, thus throwing the weight forward on the anterior surface of the tibia, and further relieving pressure in the popliteal space.

The posterior border of the socket should extend just as high as the anterior, hugging the popliteal space but with slight excavations on each side for the hamstring tendons (Fig. 14-B). An error commonly observed is that of lowering of the posterior border of the socket below the popliteal space in the erroneous belief that this will allow the knee to flex with more freedom. Cutting away the posterior border does not allow increased knee flexion and only results in bulging of the soft tissues of the popliteal space over the top of the lowered socket. This not only impairs circulation, but also allows the stump to shift posteriorly away from the anterior portion of the socket (Fig. 15-A.).

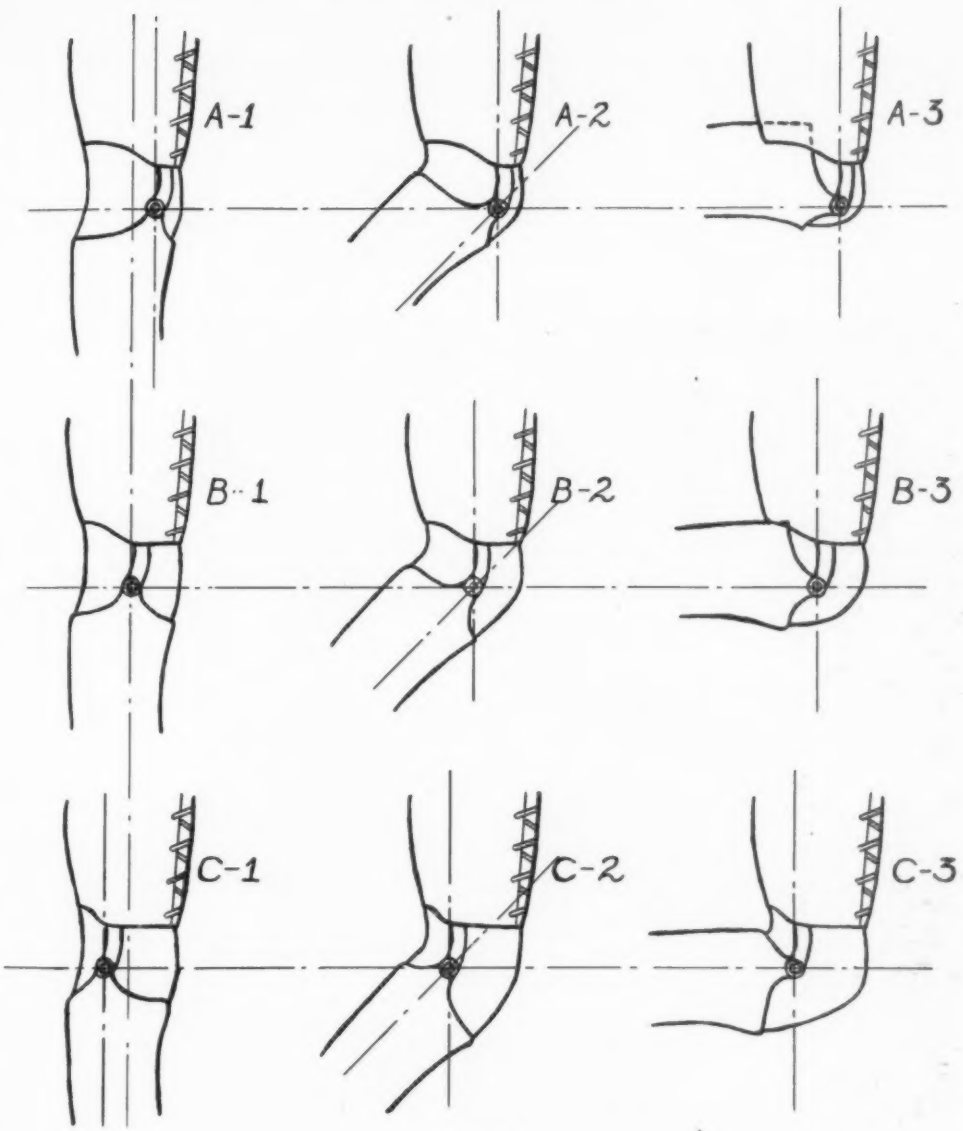


FIG. 18

Diagram illustrating the importance of correct placing of the side joints of the below-the-knee prosthesis posterior to the knee center.

A-1: The side joints are located anterior to the knee center. In this position, right-angle flexion is impossible (*A-3*).

B-1: The side joints coincide with the knee center. Right-angle flexion is possible, but only with pressure in the popliteal area (*B-3*).

C-1: The side joints are correctly placed posterior to the knee center. Full flexion is possible without any pressure in the popliteal area (*C-3*).

The position of the side joints at the knee on the below-the-knee prosthesis is of the greatest importance. Freedom of flexion without pressure posteriorly is largely dependent upon the position of these joints. They should always be set posterior to the lateral knee center, preferably at the junction of the anterior two-thirds and posterior one-third of the anteroposterior diameter of the socket (Fig. 16). Heather Bigg, in 1885, called attention to the necessity of placing these joints in this position, and offered a logical anatomical basis for so doing (Figs. 17-A, 17-B, and 17-C). As previously stated, the normal knee-joint axis is not fixed, but moves posteriorly in flexion. In the artificial limb, which of

FIG. 19

Side view of above-the-knee prosthesis, showing the positions of the hip, knee, and ankle joints of the prosthesis as related to the longitudinal axis of the limb.

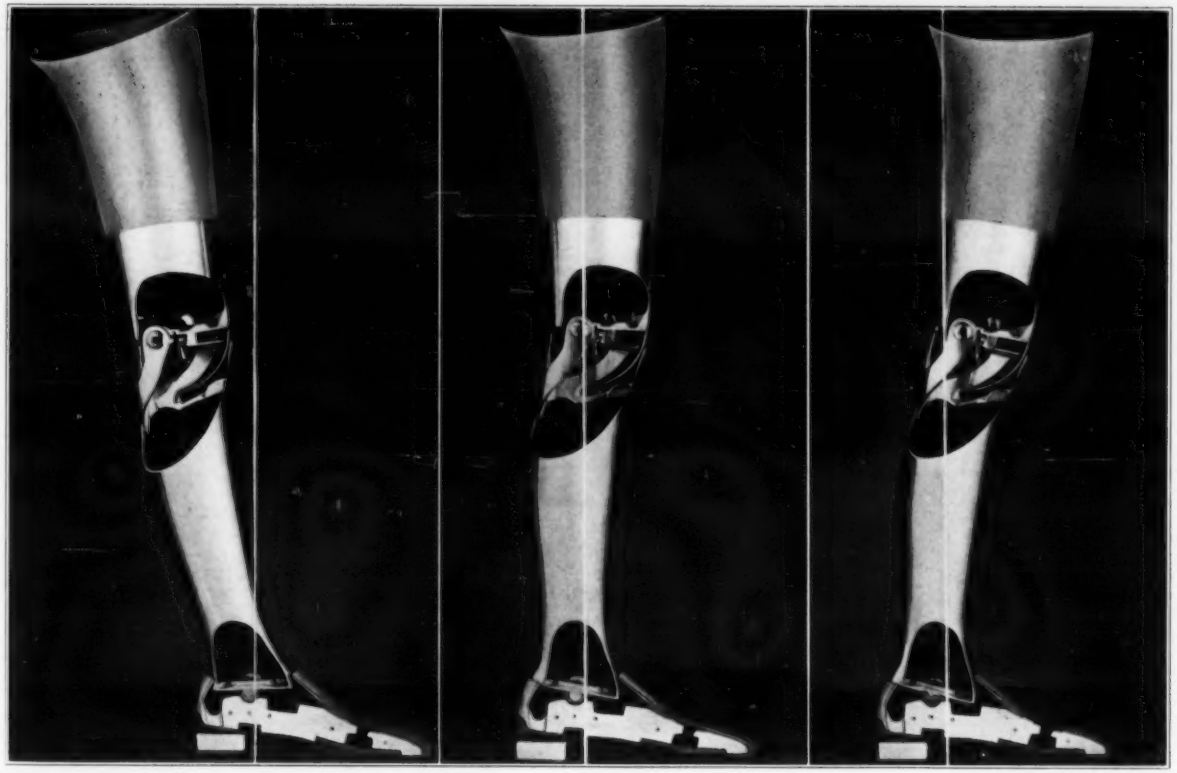


FIG. 20-A FIG. 20-B FIG. 20-C

Sectional view of above-the-knee prosthesis, illustrating the effect of different positions of the foot on knee-joint stability.

Fig. 20-A: Foot fixed in extreme plantar flexion by too high an instep cushion. This position increases stability, but causes an awkward and fatiguing gait.

Fig. 20-B: The rubber instep cushion is of correct height, holding the foot in slight plantar flexion just sufficient to maintain the center of gravity anterior to the knee-joint axis. This is the ideal position for a natural stable gait.

Fig. 20-C: The instep cushion is too low, allowing the foot to dorsiflex, thus throwing the center of gravity posteriorly, with resulting instability of the knee.

necessity must have a fixed axis, free flexion can take place only if this axis is placed posterior to the knee center. Figure 18 demonstrates this very clearly.

The Artificial Knee Joint

As stated, success in the use of the above-the-knee prosthesis depends upon stability and control of the artificial knee joint. Many ingenious and complex mechanisms have been designed and are in use for controlling knee motion. As previously pointed out, however, such control mechanisms are not always necessary. This is true in the pelvic-suspended limb, if the stump is of good length and the limb properly aligned, with the relative positions of knee and foot adjusted, so that, in walking, the center of gravity falls anterior to the knee joint. This is accomplished by placing the axis of the artificial knee joint well posterior to the knee center (Fig. 19), and by regulating the thickness of the rubber bumpers in the foot, so that the foot maintains a position of slight plantar flexion (Figs. 20-A, 20-B, and 20-C). The physiological basis for this position has already been explained.

In limbs with pelvic suspension and direct stump control, some form of knee friction or brake is necessary in order to control the forward swing of the shin piece on the knee. This friction is so adjusted that the shin swings forward and fully extends on the knee exactly at the moment that weight is applied to the limb as the heel strikes the ground, and not before. Otherwise instability of the knee will result.

Suspension of the Limb

Until recently the above-the-knee prosthesis was always suspended and controlled by means of a harness over the shoulders. With the recent advent of the pelvic suspension

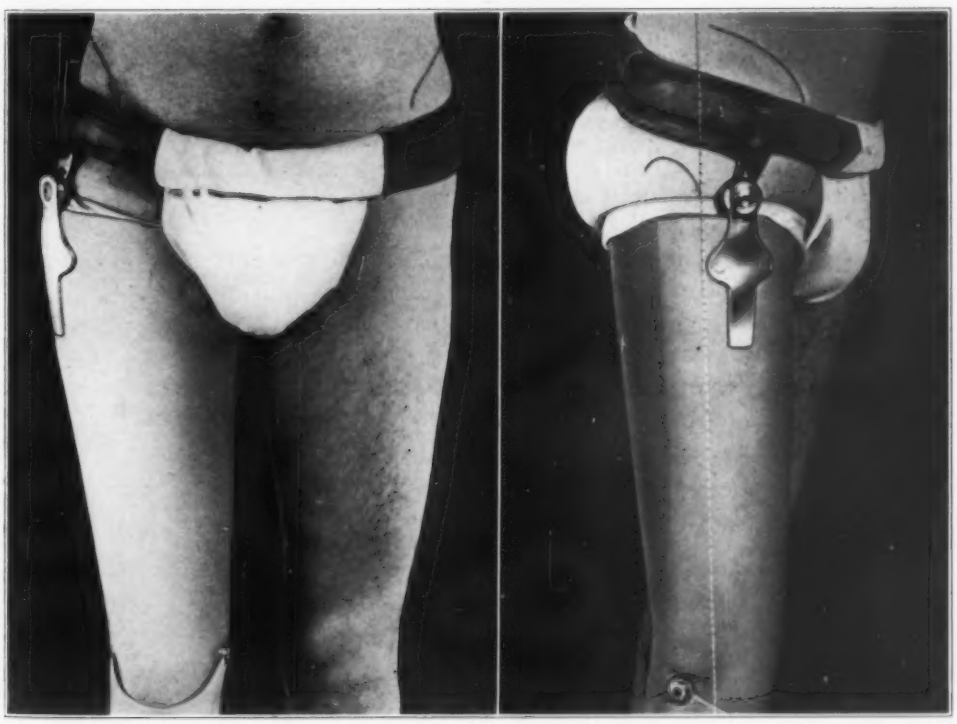


FIG. 21-A FIG. 21-B

Front and side views of thigh section of above-the-knee prosthesis, illustrating correct position of pelvic band and hip joint.

The hip joint of the prosthesis is placed to coincide with the true axis of the normal hip joint which lies well anterior to the trochanter. The correct position of the pelvic belt lies between the greater trochanter and the anterior superior spine.

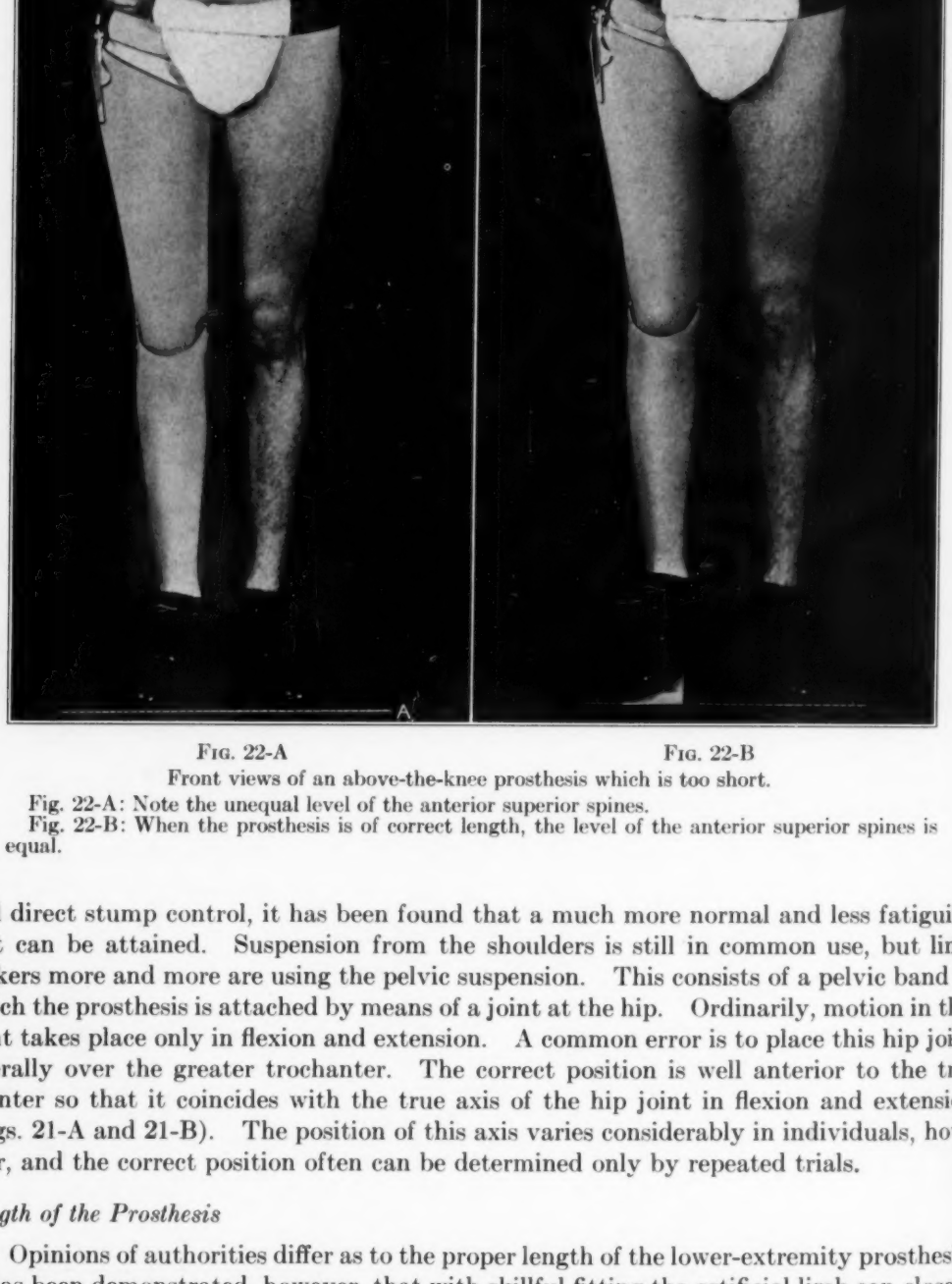


FIG. 22-A FIG. 22-B

Front views of an above-the-knee prosthesis which is too short.

Fig. 22-A: Note the unequal level of the anterior superior spines.

Fig. 22-B: When the prosthesis is of correct length, the level of the anterior superior spines is equal.

and direct stump control, it has been found that a much more normal and less fatiguing gait can be attained. Suspension from the shoulders is still in common use, but limb makers more and more are using the pelvic suspension. This consists of a pelvic band to which the prosthesis is attached by means of a joint at the hip. Ordinarily, motion in this joint takes place only in flexion and extension. A common error is to place this hip joint laterally over the greater trochanter. The correct position is well anterior to the trochanter so that it coincides with the true axis of the hip joint in flexion and extension (Figs. 21-A and 21-B). The position of this axis varies considerably in individuals, however, and the correct position often can be determined only by repeated trials.

Length of the Prosthesis

Opinions of authorities differ as to the proper length of the lower-extremity prosthesis. It has been demonstrated, however, that with skillful fitting the artificial limb can closely approximate the normal limb in length in most cases. This can always be achieved in the below-the-knee prosthesis and in most thigh-amputation prostheses, particularly when pelvic suspension is used. The exceptions are in short thigh stumps with insufficient leverage or muscle power to flex the prosthesis, in aged and debilitated persons, or in those unable to learn the proper use of their prostheses. In such cases, where shoulder suspension is necessary, the prosthesis should be one-half to one inch shorter than the normal leg, depending on the length of the stump, the muscle strength, and other conditions mentioned.

A simple method of determining the correct length of the prosthesis is to note whether or not the anterior superior spines of the iliac bones are level (Figs. 22-A and 22-B).

CONCLUSIONS

It should be emphasized that, in the successful use of the amputation prosthesis, alignment and fitting are of first importance. Materials and complex joint mechanisms are entirely secondary. Fitting of the prosthesis should be individual and should be carried out at the place of manufacture under the supervision of the attending surgeon, working in complete coöperation with the limb maker. Both surgeon and limb maker should possess a thorough understanding of the anatomical and physiological principles of limb-fitting as described here. Only by the practical application of such principles can the normal physiological gait be approached, and the amputee be enabled to use his prosthesis with the greatest efficiency and comfort, and without undue awkwardness or fatigue.

NOTE: The author wishes to express his appreciation for invaluable aid rendered in the preparation of this paper by Mr. Chester Haddan, President of the Association of Limb Manufacturers of America. Without the benefit of his wise counsel, based upon long experience in limb fitting, this work would not have been possible.

REFERENCES

1. BIGG, HEATHER: Artificial Limbs and the Amputations Which Afford the Most Appropriate Stumps in Civil and Military Surgery. London, Privately published, 1885.
2. BLY, D.: Remarkable Inventions. An Anatomical Leg with Lateral or Side Motion at the Ankle Like the Natural One. Rochester, N. Y., 1868.
3. DUCHENNE, G. B.: Physiologie des Mouvements. Démontrée à l'aide de l'expérimentation électrique et de l'observation clinique et applicable à l'étude des paralysies et des deformations. Paris, J. B. Baillière et Fils, 1867.
4. GALLIE, W. E.: The Experience of Canadian Army and Pensions Board with Amputations of the Lower Extremity. Ann. Surg., CXIII, 925, 1941.
5. HADDAN, C. C.: Amputations to Obtain Greatest Functional Value. Rocky Mountain Med. J., XXXVII, 440, 1940.
6. HANDBOOK ON AMPUTATIONS. Chicago, American Medical Association, 1942.
7. HENDRIX, G.: Les principes fondamentaux de la prothèse orthopédique du membre inférieur d'après l'étude des membres artificiels-types, confectionnés dans les ateliers de prothèse du Service de Santé de l'armée belge à Rouen. Paris, 1917.
8. GLASEWALD, E. W. H.: Beinstümpfe und Kunstbeine. Med. Klin., XXXVIII, 555, 1942.
9. KIRK, N. T.: Amputations. Hagerstown, Maryland, W. F. Pryor Co., 1942.
10. LANGDALE-KELHAM, R. D., AND PERKINS, G.: Amputations and Artificial Limbs. London, Oxford University Press, 1942.
11. LITTLE, E. M.: Artificial Limbs and Amputation Stumps. A Practical Handbook. Philadelphia, P. Blakiston's Son and Co., 1922.
12. MARTIN, FLORENT: Artificial Limbs. Appliances for the Disabled. Geneva, International Labor Office, 1924.
13. MAYER, L.: Die Mechanik des Ganges bei isolierter Quadricepslähmung. Ztschr. f. Orthop. Chir., XXXIV, 589, 1914.
14. MINISTRY OF PENSIONS: Artificial Limbs and Their Relation to Amputations. London, His Majesty's Stationery Office, 1939.
15. PIERSOL, G. A.: Human Anatomy. Ed. 6. Philadelphia, J. B. Lippincott, 1918.
16. SCHEDE, F.: Theoretische Grundlagen für den Bau von Kunstbeinen insbesondere für den Oberschenkelamputierten. Ztschr. f. Orthop. Chir., Suppl. XXXIX, 1919.
17. STEINDLER, ARTHUR: Mechanics of Normal and Pathological Locomotion in Man. Baltimore, Charles C. Thomas, 1935.
18. TODD, M. E.: The Thinking Body. New York, Paul B. Hoeber, Inc., 1937.
19. THOMAS, ATHA: The Permanent Prosthesis. J. Am. Med. Assn., CXXIV, 1044, 1944.
20. VISCHER, F.: Bau der Beinprothese im letzten und im jetzigen Kriege. Wiener Klin. Wchnschr., LV, 849, 1942.

UPPER-EXTREMITY AMPUTATIONS AND PROSTHESES *

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The only indications for major amputations of the upper extremity are severe trauma, uncontrollable infection, malignant tumors, and the rarer vascular diseases, such as thrombo-angiitis obliterans and occlusions. Fortunately, trauma severe enough to justify the removal of an upper extremity is uncommon in civilian life, and the incidence of gas gangrene, malignant neoplasms, and occlusive vascular disease is small. In war, due to missiles of high velocity, the situation is greatly altered. Although loss of the upper extremity is far less frequent than loss of the lower extremity, battle injuries result in a large percentage of arm amputations. In one series of nearly 400 consecutive amputations admitted to a hospital in this Country, the incidence of amputations of the upper extremity was 30 per cent.

Without qualification, two positive statements may be made concerning amputations of the upper extremity. First, the loss of a major portion of an upper extremity produces greater economic displacement than any single amputation of the lower extremity. Individuals without a hand are, with but few exceptions, excluded from employment which requires meeting the public. Neither the iron hook nor the gloved artificial hand is pleasing to a discriminating clientele. In some states, an individual with an artificial arm cannot obtain a license to operate a motor vehicle. Compensation laws often make the individual without an arm an undue hazard. Second, the prostheses which are available for the arm amputee substitute less satisfactorily for the loss than do those designed for the lower extremity. The only demand on the lower-extremity prosthesis is a functional one. The inert mechanism of the artificial leg can be hidden well by conventional clothing. Prostheses for the upper extremity have functional requirements, and, in addition, it is desirable that they be acceptable from the cosmetic viewpoint. The artificial hand or hook is as prominently conspicuous as the empty coat sleeve. Furthermore, there is as yet no single prosthesis for the upper extremity which satisfactorily combines both functional and cosmetic requirements. The more functional an arm prosthesis becomes, the more it offends cosmesis; and the more nearly the prosthesis approaches the lost hand in shape and appearance, the less useful it becomes to the patient. In the initial treatment

FIG. 1-A

FIG. 1-B

FIG. 1-C

Arm amputation stumps of no functional value.

Fig. 1-A: Disarticulation of the shoulder. Fig. 1-B: Through the surgical neck of the humerus. Fig. 1-C: Through the humerus at the pectoral insertion.

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 3, 1944.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Roentgenogram of amputation through the surgical neck of the humerus, showing the flexion, abduction, and rotation deformity of the humeral head.

Fig. 2-B: Roentgenogram of amputation at the pectoral insertion, showing flexion and adduction of the humeral fragment.

of an arm which has been injured severely enough to justify amputation at any level, the open circular or guillotine amputation is just as applicable as in the lower extremity. This procedure has proved equally as valuable in saving life and preserving bone length for the infected or potentially infected upper extremity as for the lower extremity, and sound surgical principles dictate its use when the possibility of infection is present. Secondary closure is easier and more sure of success in the upper extremity than in the lower extremity, because of the richness of the blood supply of the arm and forearm. The elasticity of the skin of the arm, and the fact that end-bearing is not required of an arm stump, frequently make a plastic closure of an open amputation unnecessary, if proper after-care has been given following the open amputation.

FIG. 3-A

FIG. 3-B

Photographs of extensive harness required to maintain the prosthesis in position, for any amputation from the pectoral insertion on the humerus to the shoulder.

Certain amputation stumps of the upper extremity have absolutely no functional value, and even offer very difficult cosmetic problems. Foremost among these is the stump resulting from the very disfiguring intrascapulothoracic amputation. This operation gives to the upper torso of the individual a conspicuous sloping contour from the neck to the costal margin. The only attempt at a prosthesis, which is of any use, is a pad to enlarge the shoulder and fill out the coat.

No amputation through the humerus above the level of the humeral insertion of the pectoralis major has any functional value worthy of consideration. This does not mean that the head of the humerus should be removed unnecessarily, as it tends to round out the shoulder, and from a cosmetic viewpoint is desirable. Even though an inch or two of the humerus remain, if the pectoral attachment has been lost, the end of the short piece of bone is pulled by the rotators into abduction and forward flexion. Amputations just below the pectoral attachment are also of little value in motivating a prosthesis. At this level the remainder of the humerus stays opposed to the thoracic wall, and just a little forward and backward motion of the stump is possible; this is practically valueless in moving an artificial arm. To maintain a prosthesis in place on these high amputations, an elaborate uncomfortable harness is necessary. Because of the uncomfortable harness, the weight of the prosthesis, and the uselessness of the artificial extremity, most patients ultimately discard the mechanical extremity, and go about with an empty coat sleeve.

The minimal bone length of the humerus, which will motivate an artificial arm adequately to make its use attractive to the amputee, is two to three inches below the pectoral insertion. This requires five to six inches of the humerus. Even with this length of humerus, a rather extensive shoulder harness is necessary, and the hook or mechanical hand can only be opened well with the elbow in the extended position.

The best site for an amputation through the humerus, and the bone length adapted to the most efficient use of a prosthesis, is the level just above the beginning of the flare of the condyles of the humerus. This removes two to three inches of bone above the elbow. This amputation leaves a humeral stump that is well controlled by muscles; that can be abducted, flexed, and extended; and that has sufficient strength and grip on the prosthesis to make its use attractive. The long lever makes it possible for the amputee to develop a trick swinging motion, by means of which the forearm of the prosthesis can be flexed on the arm without lifting it with the other hand, as is often necessary with shorter stumps. This long stump also stabilizes the prosthesis, so that the mechanical hook or hand can be

FIG. 4-A

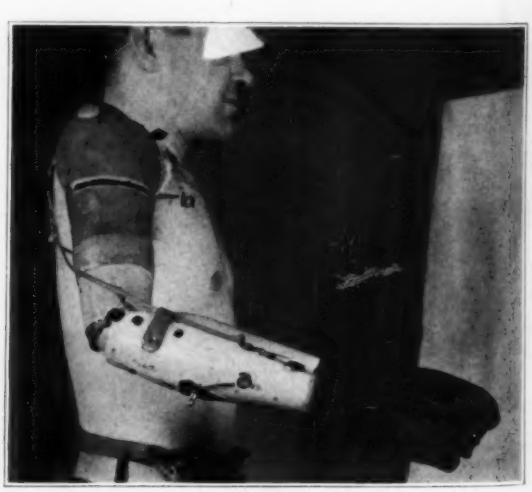

FIG. 4-B

Fig. 4-A: Minimum length of arm stump of functional value.
Fig. 4-B: Photograph of prosthesis and extensive harness necessary for stability.
a: Clip for control of elbow lock; *b:* end of stump.

opened more effectively in many more positions. This site is superior to a disarticulation through the elbow, as it allows room for the mechanism of the elbow block, without placing the elbow at a lower level than the remaining arm and thus making a disproportionate forearm. The absence of the condyles and the loss of the distal two to three inches of the humerus do not detract enough from the functional value of the humeral lever to offset the cosmetic and mechanical difficulties in the prosthesis.

The importance of saving the elbow joint, when possible, cannot be too greatly stressed. The functional value of the elbow to the upper extremity is even greater than that of the knee to the lower extremity. Without an elbow joint under voluntary control, the arm amputee is limited to a few positions of the forearm under the control of a mechanical lock, which he must unlock with the other hand to release. In close quarters, even with the ideal humeral stump, he may have to place the forearm in one of the few positions available with the other hand. Even a relatively short stump of forearm will obviate this difficulty to a large degree. An elbow joint may be of value, even though it does not have total motion and even though the condition of the humerus is not normal. As the arm is not a weight-bearing extremity, a fibrous union of the humerus may suffice for excellent use of an elbow and forearm stump, since the corset of a prosthesis will help to stabilize the humerus. No unnecessary sacrifice of the elbow or unnecessary reconstruction, which through long immobilization might lead to stiffness of the elbow, should be proposed when it will jeopardize function.

FIG. 5-A

Photograph of the ideal upper-arm amputation stump, just above the flare of the humeral condyles.

The ideal forearm stump is one through the junction of the middle and lower thirds of the forearm. This level provides enough bone length for a

FIG. 5-B

FIG. 5-C

Fig. 5-B: Roentgenogram.
Fig. 5-C: Prosthesis on arm. The stippled area is space occupied by the elbow block.

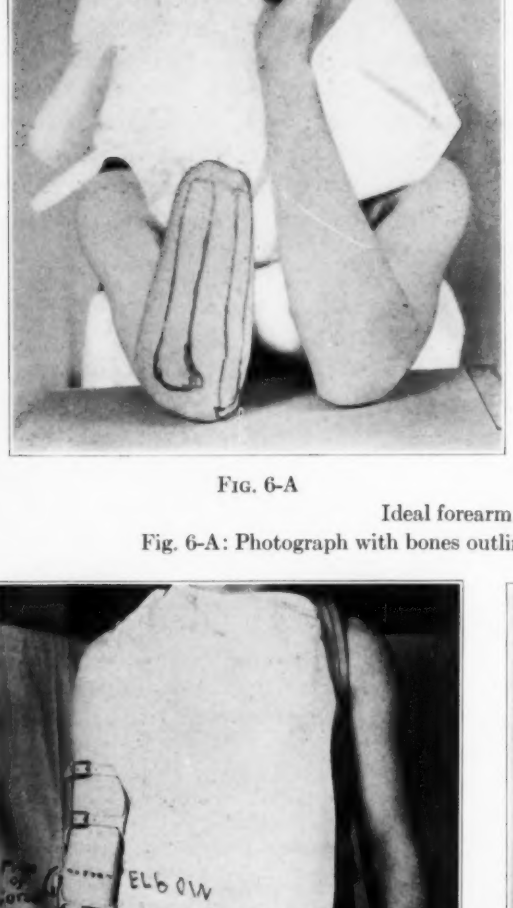

FIG. 6-A

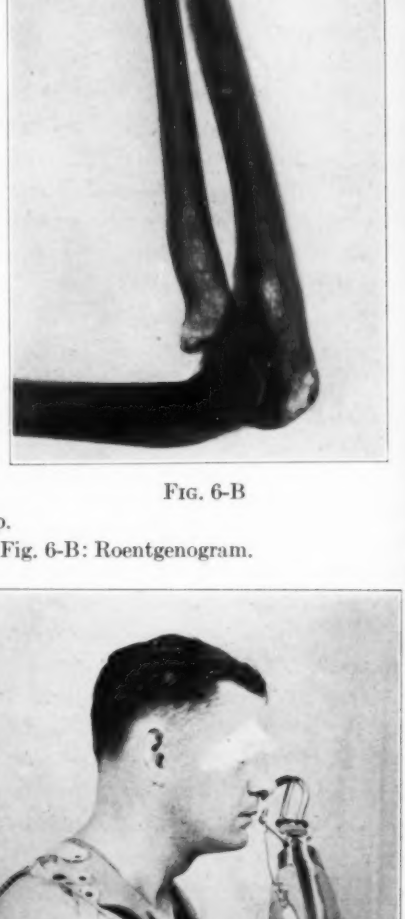

FIG. 6-B

Ideal forearm stump.
Fig. 6-A: Photograph with bones outlined. Fig. 6-B: Roentgenogram.

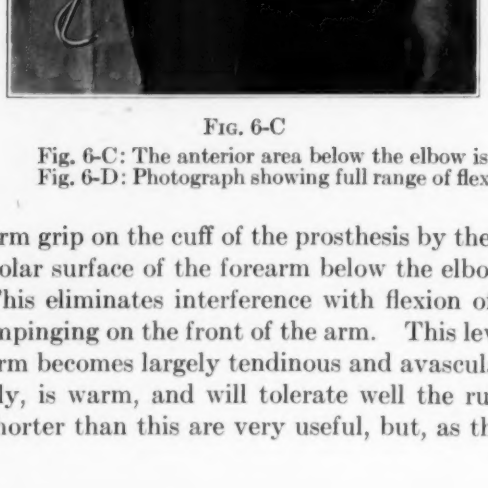

FIG. 6-C

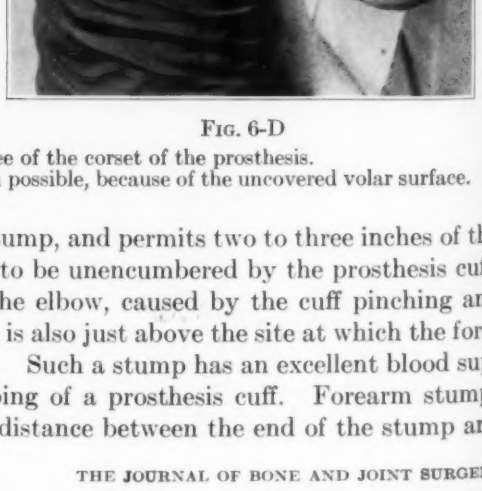

FIG. 6-D

Fig. 6-C: The anterior area below the elbow is free of the corset of the prosthesis.
Fig. 6-D: Photograph showing full range of flexion possible, because of the uncovered volar surface.

firm grip on the cuff of the prosthesis by the stump, and permits two to three inches of the volar surface of the forearm below the elbow to be unencumbered by the prosthesis cuff. This eliminates interference with flexion of the elbow, caused by the cuff pinching and impinging on the front of the arm. This level is also just above the site at which the forearm becomes largely tendinous and avascular. Such a stump has an excellent blood supply, is warm, and will tolerate well the rubbing of a prosthesis cuff. Forearm stumps shorter than this are very useful, but, as the distance between the end of the stump and

FIG. 7-A

FIG. 7-B

FIG. 7-C

Short forearm stump.

Fig. 7-A: Photograph of three-inch stump.
Fig. 7-B: Prosthesis. Shaded area is the corset, which must cover the volar surface of the forearm and impinges on the antecubital space when the elbow is flexed.
Fig. 7-C: Photograph of maximum flexion possible with the prosthesis. The patient cannot bring the hook to his mouth.

the insertion of the biceps decreases, the necessity for covering a greater proportion of the volar surface is increased, and flexion of the elbow may be interfered with by the encasement of the prosthesis. In the lower third of the forearm, after the muscles have merged with their tendons, there is poor circulation, as only main arteries traverse this area. Stumps through this area are cold and many times cyanotic. Ulceration of the skin is not uncommon in stumps in the lower one-third. The difference in temperature at these two levels can be easily detected by palpation with the hand.

Disarticulation through the wrist joint is not a good amputation. It has all the disadvantages of a stump in the lower third of the forearm. In addition, the inferior radio-ulnar joint may be very painful on pronation and supination. The loss of its carpal attachments and abutments causes a loss of stability of this joint which produces pain. The prominent subcutaneous styloid processes are prone to become abraded in the prosthesis, and the stump end is likely to be sensitive.

The stump which contains the proximal or proximal and distal rows of carpal bones is, however, a very useful and satisfactory stump from the functional viewpoint. From the cosmetic aspect, it has a few disadvantages. The reasons for the superiority of this stump to the disarticulation through the wrist are obvious. First of all, it must of necessity be covered by tissue with a good blood supply,—as the palmar flap of the heel and upper half of the hand. Second, the inferior radio-ulnar joint is stable and painless, because of the presence of its normal abutments and ligamentous support. Third, there are no bony unpadded prominences. The length of the stump containing carpal bones, together with the slight voluntary flexibility of its distal end, make it of considerable aid to the patient without a prosthesis. This stump can be used satisfactorily for a stabilizer in such activities as driving a car, tying shoe laces, tying a necktie, buttoning a coat, *et cetera*. This stump also requires a great deal less harness to maintain the prosthesis in place and to powerfully motivate it.

The disadvantage of an amputation at the carpal level is largely in the fitting of a functional prosthesis. Because of its length, the mechanical hand or hook must hang at a lower level

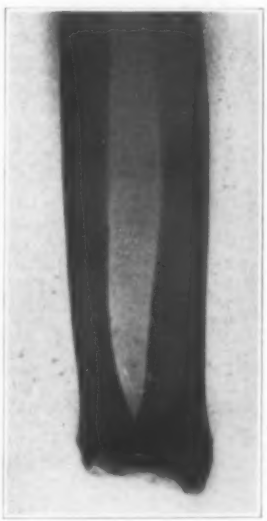

FIG. 8

Roentgenogram of disarticulation through the wrist. This is a poor amputation stump, because of cold cyanotic skin, subcutaneous bony prominences, and unstable deranged inferior radio-ulnar articulation.

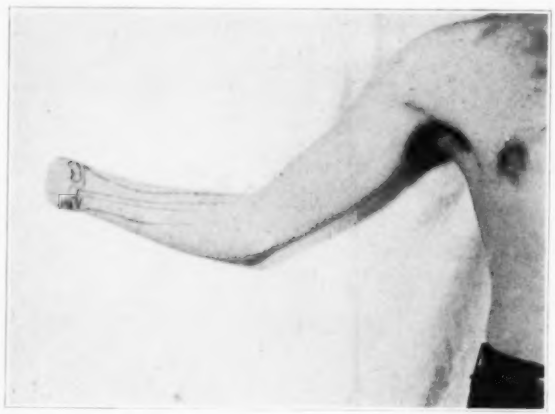

FIG. 9-A

FIG. 9-B

An amputation stump containing proximal row of carpal bones and covered by palmar skin is an excellent stump.

Fig. 9-A: Photograph, showing the bones outlined.

Fig. 9-B: Roentgenogram.

FIG. 9-C

Fig. 9-C: Only a light harness is required for operating the prosthesis.

Fig. 9-D: Powerful control of split hook in any position is possible.

FIG. 9-D

than the remaining good hand, since the necessary mechanism takes up space. This stump, however, lends itself well to the application of a purely cosmetic type of restoration,—such as those made of latex and plastics.

Amputations which remove all the digits at the metacarpophalangeal joints also constitute a major disability. To supply gripping and lifting power, a prosthesis is necessary. Since the end of the thumb cannot go powerfully against the end of the palmar stump, a stable post to which it may be opposed must be supplied, and also, a hook for lifting.

The indications for the cineplastic amputation are few. Experience with this procedure following World War I was unsatisfactory, and many of the individuals who had motor tunnels made after the War of 1914 to 1918 later had them removed. It is probable that the operation of cineplasty does have a very limited application for individuals doing certain types of specialized work, and that it may have an application in bilateral amputations of the upper arm. It is a simple surgical procedure that is non-mutilating, and it would seem that in certain well-selected patients its trial might be justifiable. The skin tunnels can be easily removed without detracting in any way from the previous value of

FIG. 10-A

Amputation of all fingers through the metacarpophalangeal joints is a major disability which requires a prosthesis.

Fig. 10-A: Roentgenogram.

Fig. 10-C: A useful prosthesis for this type of amputation.

FIG. 10-B

FIG. 10-C

Fig. 10-B: Photograph The hook may be removed when not in use for lifting.

the stump, if they are found unsatisfactory. The prosthesis of most use is the split hook. Although the hook is not pleasing in appearance, it enables an individual to do many things. With will power enough, a person who has even two forearm amputations can become a useful citizen, if he will master the use of the hooks. For agricultural work or occupations which require repetitious actions,—such as using a pitchfork, wheeling a barrow, hoeing, *et cetera*—the Bowler hook is superior to the split hook.

The mechanical hand for general use is far inferior to the split hook. The only motion possible in the mechanical hand is opposition of the thumb to the fingers. In most hands the grip is poor, and certainly, from a cosmetic viewpoint, the glove which is worn on the hand is conspicuous and calls attention to the disability.

The most effective attitude toward a prosthesis, and one which the arm amputee must acquire before he will make progress toward normalcy, is that the arm prosthesis at best is "a tool-holding device". This principle has been used for a long time in Canadian and British arm prostheses, and

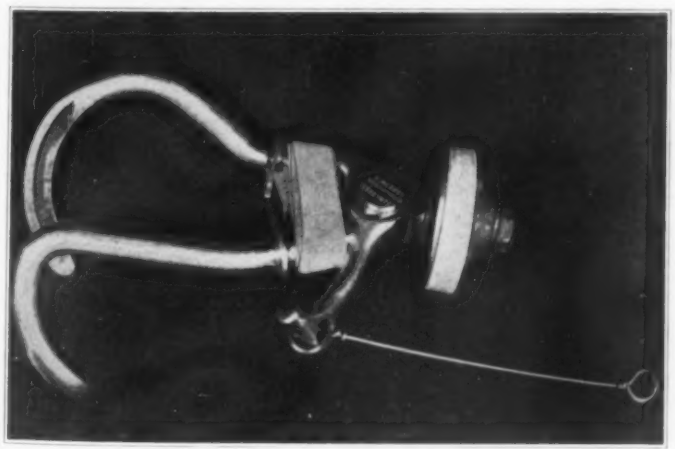

FIG. 11-A

The split hook, opened by a strap to the opposite shoulder and closed by a rubber band, is the most useful of all appliances.

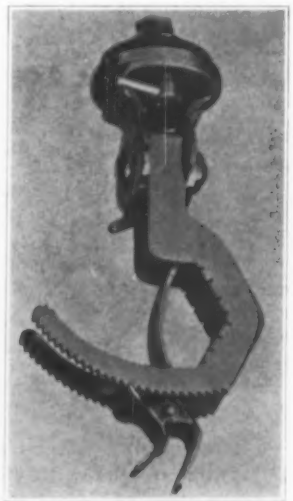

FIG. 11-B

The Bowler hook is a useful appliance for work requiring repetitious actions.

FIG. 12-A

The prosthesis utilizes a chuck which may be set at a number of angles around the circumference of a circle.

FIG. 13-A

Cosmetic latex hand. This dress hand has no functional value.

FIG. 12-B

Some appliances which may be inserted into the chuck. The variety of tools is unlimited.

FIG. 13-B

Fig. 13-A: In white.
Fig. 13-B: In black.

FIG. 14-A

FIG. 14-B

Cosmetic latex hand on patient.

Fig. 14-A: Caucasian.

Fig. 14-B: Negro.

recently has appeared in American-made prostheses. By using a chuck at the end of the prosthesis, and making different tools to meet different demands, the scope of usefulness of the prosthesis can be greatly broadened. Each amputee has his own individual problems, and his own approach to these problems. A device suited to any need can be slipped easily into the chuck at the end of such a prosthesis.

To some individuals and to some occupations, the cosmetic aspect of the prosthesis is the most important consideration. Recent developments in plastics and latex have given rise to possibilities along these lines, and, in individual instances, certain lifelike hands

have been produced. However, cosmetic hands of this quality at present are not an article of general distribution, and their production requires the time and talent of a craftsman with artistic ability and training. Such prostheses at their best will not stand close scrutiny, and will only pass for the normal hand in a crowd or in poor lighting. Such prostheses are also of absolutely no functional value. If vanity demands their use, the individual becomes totally one-handed.

SUMMARY

1. The economic displacement of an individual with a major amputation of the upper extremity is much greater than of one with an amputation of the lower extremity.

2. Prostheses for the upper extremity are less satisfactory than those for the lower extremity.

3. The open circular amputation should be used for any potentially infected amputation of the upper extremity.

4. Arm stumps from the level of the pectoral insertion to the shoulder have no functional value.

5. The humeral stump of choice is one just above the flare of the humeral condyles.

6. The forearm stump of choice is one at the junction of the middle and lower thirds of the forearm.

7. Disarticulation through the wrist produces a poor stump.

8. Forearm stumps containing carpal bones and covered by palmar skin are satisfactory.

9. Artificial hands are of little value.

10. The most useful appliance for a prosthesis is the split hook. For repetitious work the Bowler hook is more useful.

11. The practical attitude to take toward an arm prosthesis is that it is "a tool-holding device".

12. Completely cosmetic hand restorations will not stand close scrutiny, and have absolutely no functional value.

DISCUSSION

MAJOR-GENERAL NORMAN T. KIRK, WASHINGTON D. C.: I am asked to discuss and summarize the excellent papers we have just heard. It seems to me there is not much left to be said. I want to congratulate all these essayists on what they have brought to us. I think we should all be well pleased. I am happy to hear how well the amputees in World War II are taken care of. What has been shown here today, what is being carried out in Canada, and what is being done by the orthopaedic surgeons of the United States in all the Amputation Centers is most gratifying. It did not "just happen". There was a plan for all this, and great credit is due the men who are putting these plans into execution.

A training film was planned and was made through the cooperation of the American Legion; it is shown in every Amputation Center at home and in hospitals overseas, and tends to improve the morale of the soldier who has lost an upper extremity. I think it is excellent.

Dr. Thomas told us what he has done in the field of prostheses for the lower extremity. Too many doctors and orthopaedic surgeons who do amputations know nothing about the fitting of a prosthesis. None of us can tell whether or not an amputation stump can be properly fitted with a prosthesis, unless we know something about the subject. I know the amputees in Canada are well fitted, because the fitting is done under the supervision of the surgeon who did the amputation.

There is only one thing with which I might take issue, and that is the location of the knee joint on the prosthesis. We believe it might be properly placed a little forward and to the center rather than behind.

I agree completely with Colonel Harris. The Canadian Government has made available to us an excellent Syme prosthesis, which we have copied. I think the reason we did not like a Syme stump was because we did not know how to fit it. We feel that a supracondylar tendoplastic stump is as good as a Gritti-Stokes. It has been shown by Colonel Harris that an amputation may be done after the manner of a Gritti-Stokes, using guillotine flaps, and it does not make any difference where the scar falls. The stump must be covered with healthy tissue. We believe that, from a prosthetic standpoint, the below-the-knee stump should not be too long or too short. We believe that a little pressure on the stump can give additional support to assure

weight-bearing. We agree that two of the best stumps in the lower extremity are the end-bearing Syme and the supracondylar, whether of the Gritti-Stokes or tendoplastic type. I think it has been definitely proved that skin grafts will not hold up under a prosthesis, and we are not justified in putting skin grafts on a stump and expecting them to hold.

Colonel McKeever has shown beautifully how to rehabilitate the amputee who has lost an upper extremity.

As shown in Colonel Peterson's paper, on statistics of World War I, there were a larger number of amputations above the knee than below the knee. One reason is that we did amputations in World War I to save life from gas gangrene. Amputations for gas in this War have been infrequent. Most of them have been necessary because of destruction by land mines, which we did not have so extensively in the last War. The use of land mines has increased our amputations. It is good to see that only 6.2 per cent. of patients with amputations undergoing secondary surgery had complications, compared to the last War, when we did not have the sulfonamides or penicillin. Then we did not do closures until the stump was free from streptococci, but we had considerable infection. Our Army prefers the circular-type of open amputation, called the guillotine, which is somewhat of a misnomer. Another operation has to be done before we can get a satisfactory stump. A circular amputation requires proper skin traction during the first weeks. We believe that secondary repair of an open amputation gives us a better stump than the stump obtained by early secondary closure.

DR. HAROLD R. CONN, AKRON, OHIO: This presentation has been comprehensive and most timely, but even with the large number of cases here represented, let us not forget that a bigger problem presents itself each year among civilians. During the past three months, I have tried to get some actual statistics on the number of industrial amputations done in the United States each year, but there are no figures available. However, the limb manufacturers say that they make and fit 75,000 prostheses each year, and this gives some idea of the magnitude of this amputation problem. If anything can possibly be said in favor of war, it is, perhaps, that it gives us an opportunity to survey problems like amputations *en masse*, to appraise surgical methods, and to study the problems of prostheses and rehabilitation.

There is one thing that civilian surgeons miss, but which is well recognized by military surgeons, and that is that, in a primary circular amputation, the muscles become adherent to the bone, and later revision of that stump is likely to yield a better result than is possible with any primary amputation. Too much effort is made by the civilian surgeon to do a primary amputation with immediate closure, with all its attendant risks.

It was a privilege recently to look over three of the Army Amputation Centers and some 500 cases. Comparing today's results with approximately the same number when I was in charge of the Amputation Service at Walter Reed Hospital twenty-five years ago, there are striking differences. Most impressive is the almost complete absence of sick and septic patients, or patients with local cellulitis and terminal infectious oedema. This can be attributed to the excellence of the initial surgery, and to the judicious use of chemotherapy. In turn, this control of infection permits quicker and safer surgical revision; the results are beautifully tailored and almost scarless stumps.

The infrequency of neuromata was an equal surprise. In the days of alcohol injections and "fishtailing" of the nerve sheath and suture, it seemed to me every other patient presented these painful tumors. How different today, when not over eight or ten neuromata were found among the relatively high number of patients examined. It does not seem possible that the present Army method of simple high division of the nerve can alone be responsible for the improved result. A few moments ago I asked Lieutenant Colonel Thompson if he thought the control of infection was an important factor in the prevention of neuromata, and he replied, "Very certainly".

Continuing the comparison between then and now to include prostheses, the most striking improvement noted was the pelvic band or pelvic control used by the Army to replace the shoulder harness. You all recall the characteristic vicious limp of the above-the-knee stump, which began with a shrug of the shoulder to be followed by a semicircular outward swing of the foot with the knee held rigid. We attributed some of this limp to the peg-leg gait induced by the pylon, which was one of the reasons for adopting the provisional prosthesis. The pelvic band practically eliminates this complication. Likewise, it controls the rolling of a short thigh stump in the bucket, and, in my opinion, is a major contribution to the problem of the above-the-knee fitting.

Through the efforts of Colonel Robert I. Harris, the Amputation Panel of the Sub-Committee on Orthopaedic Surgery of the National Research Council was invited to attend a Conference on Amputations, sponsored by the Research Council of Canada, in February of this year, in Ottawa and Toronto. Under Colonel Harris's direction, the meeting became international in scope, with representatives from the Military Forces of Canada, Great Britain, Australia, Holland, Russia, and the United States, together with representatives of the British and Canadian Ministries of Pensions and our own Veterans Administration all attending. We were magnificently entertained and greatly enlightened. Colonel Harris has edited and condensed the proceedings of the Conference, a tremendous task for which we are most grateful.

The Canadian Ministry of Pensions presented a considerable group of Syme amputations, of twenty-five years' duration, which convinced most of us that the value of the Syme procedure has not been properly appreciated.

Quoting their valuable statistics, the British Ministry of Pensions reported that the average tolerance of a below-the-knee stump, fitted with a lateral or tibial-bearing appliance, was only about eight years. They, therefore, favor ischial-bearing for all below-the-knee stumps, and, under certain circumstances, a reamputation above the knee. This statement I found surprising, and shortly after the meeting I availed myself of the opportunity to survey the employees of an industry with 101,000 employees, who recently have accepted a considerable number of amputees for war-time employment. The findings completely verify the experience of the British Ministry of Pensions. Not one man with a below-the-knee amputation could endure eight hours of bench work or a similar period of walking. However, five men with Stokes-Gritti or long thigh stumps were working steadily without complaint. Furunculosis, terminal oedema, recurrent cellulitis, and ulceration about the tibial head were the causes of recurrent disability with the lateral-bearing stumps. Obviously, we must either improve our below-the-knee fittings, or be more willing to sacrifice the knee in certain skilled artisans.

We have heard splendid presentations today on every phase of amputations except one of the most important,—namely, the psychological readjustment of the patient himself. The amputee is spectacularly mutilated, and he incites pity and often revulsion among friends and family. He is very conscious of this, and fearful that his wife or the lady of his choice may be unable to overcome the more or less natural abhorrence of the normal individual for the cripple. He wonders whether he can marry and support a family in competitive civilization, and almost always suffers a profound mental depression. Occupational rehabilitation is not enough. How often we have seen an amputee, depressed, dissatisfied with his prosthesis, apathetic as regards the future, refuse a leave, in order to avoid the ordeal of the first contacts with his friends, his family, and possibly his fiancée. When finally he faces the test, he returns either more depressed or a changed personality.

The military surgeon has not done his full duty when he has fashioned a perfect stump and fitted a good prosthesis. He still owes the amputee all possible help toward making a psychological readjustment.

During the Canadian Conference we received a beautifully worded invitation to be the guests at dinner of "The War 'Amps' of Canada", an organization numbering some 3,000 of the original 4,000 amputees of World War I. I am certain I speak for every guest when I say that it was the most amazing and inspiring dinner we have ever attended. The "Amps" desire no pity. On the contrary, they are fully cognizant of the sacrifice they have made for their Country, and they wear their artificial limbs proudly as badges of honor. They have helped each other to face life and the future with brave hearts, and they thanked us as surgeons for their scars and their lives.

In this War, the "War Amps" receive from overseas the names of all amputees, and the level of amputation; two similarly maimed men call on the next nearest of kin, in order to prepare them for the soldier's return. Equally important, a delegation of the "War Amps" meet every convoy of wounded, so that, even before reaching the hospital, the depressed victim of this War finds himself a member of a courageous band who understand his problems and encourage and stimulate him to seek rehabilitation.

The film "Meet McGonegal" I enjoyed, since I recall him as a patient, and it proves what courage can do. I wonder, however, what happened to the soldier with a similar double amputation, who occupied the next bed, and who refused even to try to wear his hooks, and who insisted that his bed be constantly screened. He suffered a depression bordering on psychosis, and he needed the "War Amps".

We have borrowed many good things from our Canadian Allies, for which we are grateful, and now I wish we might borrow their "War Amp" organization. Until some similar society of proud War amputees has been sponsored, I feel that we will not have done our full duty as physicians to our steadily growing list of War victims.

Dr. Philip D. Wilson, New York, N. Y.: I have listened to the program on amputations this morning with great interest. It is a subject that occupied a large part of my time and attention in the last War, and I have had the opportunity of seeing some of the work being done in our Amputation Centers in this War. There is no doubt in my mind that important advances have been made, not only in the surgery of amputations, but also in planning for the rehabilitation of the amputees. The speakers this morning have given us an excellent presentation of the Army program of treatment, from the time of injury to the discharge of the wounded soldier. As General Kirk has said, this program did not develop accidentally; it was planned. We all know that General Kirk has a great many matters to think about. Amputations are only one small item among these interests; but it happens to be his particular hobby, and he is the one who is responsible for the development of this splendid program for the amputees of the Army.

The guillotine amputation is not only the safest method for use in the field, but it also results in a stump with the greatest functional value. When combined with proper after-treatment by skin traction, followed later by scar excision and plastic closure when necessary, the best type of stump for use in an artificial limb

(*Continued on page 706*)

ACUTE MANIFESTATIONS OF YAWS OF BONE AND JOINT

BY ARTHUR J. HELFET

Lieutenant Colonel, Royal Army Medical Corps

INTRODUCTION

The native legions in the armies of the United Nations are expanding. The problem of endemic yaws faces every medical officer in charge of native troops in West and East Africa, Ceylon, parts of India, the East Indies, and other parts of the world. Yaws is a cause of cracked and painful feet; it is said to play a rôle in that medical conundrum, the "tropical ulcer", and it is the most common disease of bones and joints in the tropics. To keep the troops in the field it is, therefore, essential that the disease be successfully diagnosed and treated.

The problem is the more complex in that manifestations of yaws are so similar to those of syphilis. The textbook distinctions are that yaws is not a venereal disease, and that it rarely attacks the viscera or the central nervous system. However, both diseases tend to attack bones and joints. The author has had the opportunity of studying these diseases for eighteen months in West Africa, and now believes that certain features occur, at all events more constantly, and probably solely, in yaws, thus allowing it to be distinguished from syphilis.

FIG. 1

FIG. 2

Fig. 1: Case 1. Chronic yaws of the tibia in an African soldier. The only symptom was "bone pain" after marching a few miles. This improved after a course of arsenicals.

Fig. 2: Case 2. Acute yaws of the humerus and radius in an African woman. She gave a history of injury a few weeks previously, which had been followed by pain and swelling of the arm and forearm and limitation of movement of the elbow joint. The symptoms had been increasing in severity. The roentgenograms show subcortical necrosis of bone and a marked periosteal reaction in both the humerus and upper end of the radius. Note the resemblance of periosteal calcification to the "sun-ray" appearance of osteogenic sarcoma.

FIG. 3

Case 3. Chronic yaws of the radius in an African girl. The patient had had no symptoms until two days previously, when she had injured her wrist in a fall. Since then pain, swelling, and weakness had been present. There is a crack in the cortex of the bone over the diseased area.

FIG. 4-A

Case 4. November 10, 1941. Acute yaws of the humerus in an African soldier. The roentgenogram shows subcortical necrosis and periosteal reaction; they were accompanied by pain, swelling, muscle spasm, and limitation of movement of the elbow. The disease was not recognized as yaws at this stage.

FIG. 4-B

December 8, 1941. Four weeks later the disease had extended and still showed signs of activity. Treatment by the injection of arsenicals was commenced.

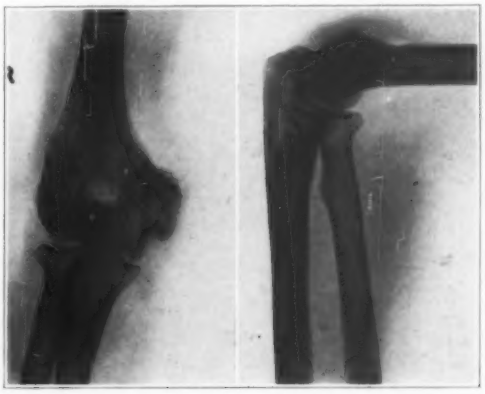

FIG. 4-C

January 17, 1942. Within ten days of the commencement of treatment, pain and muscle spasm had decreased rapidly. Six weeks later, the roentgenograms showed consolidation of the bone lesion. The patient returned to his Unit.

Hackett[1] in his comprehensive monograph gives the picture of chronic yaws, which he obtained by examining whole tribes in areas where the disease is prevalent. His paper, therefore, stresses the chronic and latent changes that yaws produces in the skeleton. It is the purpose of this paper to describe the more acute type of bone and joint lesion,—the type that requires urgent treatment.

The investigation was handicapped by the fact that the African has but little appreciation of the passage of time. Records of past history are, therefore, unreliable. Many natives also suffer from chronic malaria and may be infected with entamoeba histolytica. Most play host to one or more varieties of helminths. These conditions played no part in causing the bone and joint lesions, and were treated only when they produced their specific symptoms.

SYMPTOMS AND SIGNS

Syphilis tends to attack bones and joints slowly and silently. The symptoms are often no more than an ache or a pain at night, or when the limb is warm or dependent.

This is "bone pain" which we associate with sclerosis of bone, and it is common also in Paget's disease. Only occasionally does syphilis manifest itself more acutely.

Stannus and Hackett, in their authoritative articles, reviews, and monographs, cite similar symptoms as typical of yaws. It was the author's experience, however, that, in those cases of yaws sent to hospital for treatment, the disease presented a more rapid and painful picture. The patient rarely gives a history of more than a few weeks, and it may take no longer for marked bone changes to develop, as seen in the roentgenograms (See Figures 4-A, 4-B, 8-A, and 8-B). Whereas in syphilis a gummatous attack on a joint surface may not even be accompanied by muscle spasm or limitation of movement, in yaws a juxta-articular lesion may simulate arthritis of the joint itself, with pain, tenderness, swelling, muscle spasm, and limitation of movement. Where the shaft of a long bone is involved, a picture resembling a septic osteomyelitis may result, with intense pain, swelling, and pyrexia, although the fever is rarely high.

The onset so frequently follows trauma, often severe, that trauma cannot be discounted as a localizing, precipitating factor in what was a generalized but latent disease.

FIG. 5-A

Case 5. Acute yaws of the clavicle in an African civilian. The patient had recently suffered from pain and swelling. The roentgenogram shows necrosis of bone and periosteal reaction.

FIG. 5-B

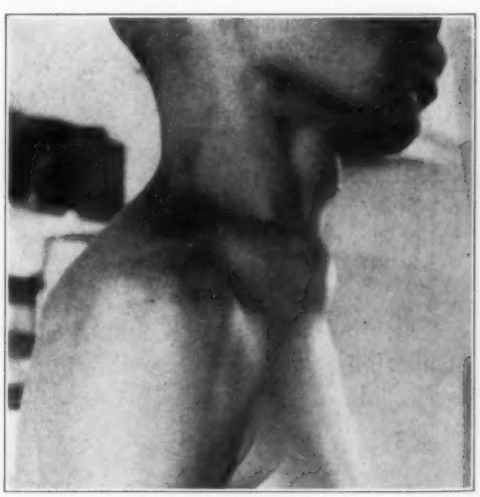

FIG. 5-C

Photographs showing the enormous size of the swelling.

FIG. 6

FIG. 7-A

FIG. 7-B

Fig. 6: Case 6. Acute yaws of the fourth lumbar vertebra in an African soldier. Roentgenogram shows unilateral necrosis of bone and marked ligamentous calcification. The patient complained of pain of recent onset. Clinical examination revealed an almost rigid lumbar spine. The pain began to subside within ten days of commencement of treatment.

Figs. 7-A and 7-B: Case 7. February 14, 1941, an African civilian was admitted with yaws of the spine. Roentgenograms show subcortical necrosis of bone and marked calcification of the ligaments. This patient gave a history of three months of pain in the back, chiefly on the right side. On examination he had a rigid, painful back with some swelling of the muscles on the right side in the thoracic region. As septic muscle abscesses are common in tropical Africa, the swelling was incised, but no pus was discovered. He was running an intermittent temperature which usually rose to 100 degrees, but never above 101 degrees. Besides a positive Kahn, he was found to have pus cells in the urine and entamoeba histolytica in his stools. A course of sulphapyridine had no effect on his temperature or on the pain and muscle spasm, nor did a course of emetine. However, on April 26, a course of novarsenobillon was started. On May 6 his temperature was normal and did not rise above an occasional 99 degrees from then until he was discharged on July 1, when, although his spine was still rigid, he no longer complained of pain.

FIG. 8-A

FIG. 8-B

FIG. 8-C

The onset may be heralded by fever and widespread "rheumatic" pains, both of which last a few days. Owing to the prevalence of chronic malaria, which has similar features, yaws is often diagnosed as such, and treated with quinine. It is not until localizing symptoms and signs present themselves that yaws is suspected.

FIG. 8-D

FIG. 8-E

Fig. 8-A: Case 8. November 21, 1941, an African soldier was admitted to the Hospital with a fracture of the shaft of the left humerus. A week later, he ran a temperature and complained of "rheumatics" for which he was treated with quinine. Follow-up roentgenograms revealed that a generalized bone disease was developing. Unfortunately, the first serological test was reported as being Kahn negative. Another cause was sought. No Bence-Jones protein was found in the urine. The blood picture was not abnormal. Although no expansion of bone was shown in the shafts of the long bones, roentgenograms of the skull and right fifth metacarpal made one suspicious of generalized fibrocystic disease, but the blood calcium was normal, although blood phosphorus had risen to eight milligrams per 100 cubic centimeters of blood. Further serological tests were done, and the second and third Kahn tests were reported positive.

Figs. 8-B, 8-C, 8-D, and 8-E: January 26, 1942, showing progress of the disease. Treatment was commenced on this date, and within three weeks the patient returned to his Unit, and the course of arsenicals was completed by his Medical Officer.

Fig. 8-F: February 19, 1942, showing the extent of healing which had occurred in the humerus.

FIG. 8-F

The tibia, the lower end of the femur, the inner end of the clavicle, and the lower end of the humerus appear to be the sites of election. Examples of the disease, however, were observed in many other parts of the skeleton, including the spine (See Figures 6, 7-A, and 7-B), and there was one case of a rather acute generalized affection (See Figures 8-A through 8-E).

Hackett [2] states that palmar and plantar skin lesions, early or late, are rarely present when bone is involved. This was also the author's experience. In no case did the bone lesion ulcerate through the skin.

The Wassermann and Kahn reactions are, of course, invariably positive.

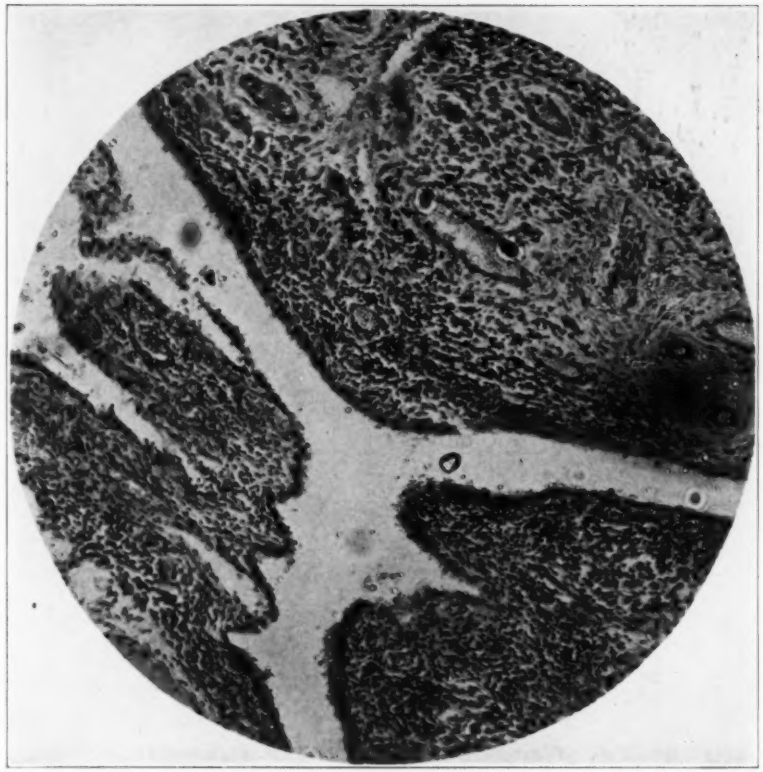

FIG. 9

Case 9. Photomicrograph of a section from the synovial membrane of an affected knee joint.

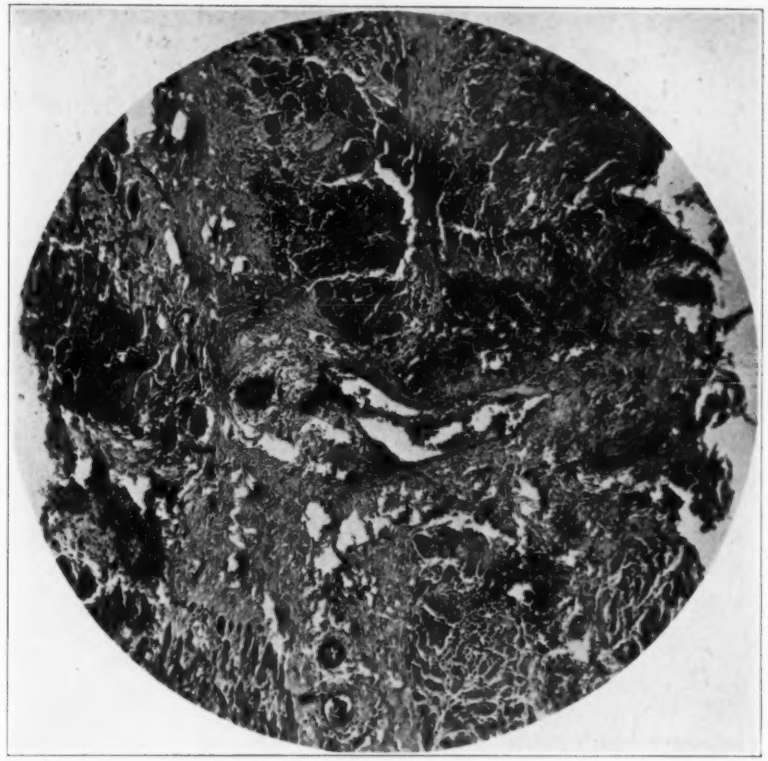

FIG. 10-A

Case 10. Photomicrograph of a section taken from a swelling in the thigh of an African soldier.

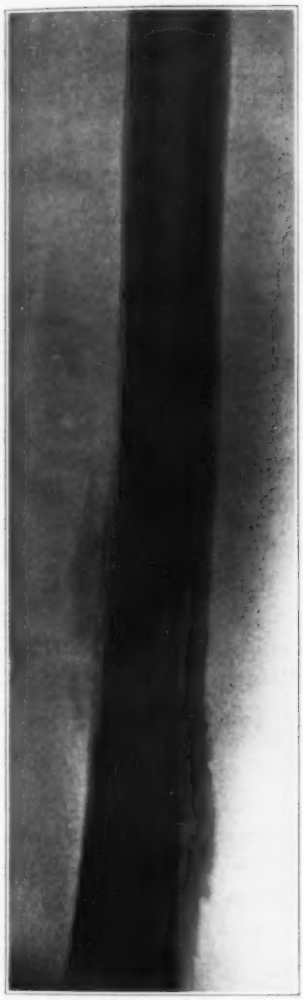

FIG. 10-B

FIG. 10-C

Fig. 10-B: February 26, 1942. Roentgenogram shows subperiosteal necrosis and "onion-layer" periosteal reaction. The symptoms were recent and akin to an acute osteomyelitis. At this stage it was not recognized as yaws.

Fig. 10-C: April 2, 1942. Five weeks later there was a marked increase in both destruction of bone and the periosteal reaction.

Roentgenographic Examination

A picture, resembling that frequently observed in syphilis, may show increase in diameter of the bone, marked increase in density, and single or multiple "punched-out" areas (Figs. 1 and 3). More often, however, in this rapidly progressing type of yaws, the roentgenograms show subperiosteal necrosis of the cortex, with raising of the periosteum and the deposition of periosteal new bone (Figs. 2, 4-A, 4-B, and 12).

Occasionally, this deposition of periosteal new bone is so marked that the roentgenographic appearance resembles that of an osteogenic sarcoma (Fig. 2) or the "onion-layering" of a Ewing's tumor (Figs. 10-B, 10-C, and 11). The rapidity with which the roentgenographic appearance of the bone may change is shown in Figures 8-A, 8-B, and 8-F.

Pathology

The lesions consist of oedematous, almost myxomatous-appearing tissue. Where the calcified periosteal layer is raised, it is separated from the bone by a homogeneous layer

of gelatinous appearance. The necrotic bone has an indeterminate gritty texture, and is so soft that it can be scooped out with a sharp spoon. A microscopic section resembles that of a syphilitic lesion, with small round-cell infiltration, many plasma cells, and perivascular cuffing, but with little or no endothelial reaction in the blood vessels,—that is, endarteritis obliterans, which is so characteristic of syphilis, is rare (See Figure 10-A). The picture of yaws is, therefore, more vascular than that of syphilis. It is suggested that it is this vascularity which is the reason that yaws produces its changes more quickly, and that the symptoms are more severe than those of the drier syphilitic gumma. At the same time, this would explain why the disease responds so rapidly, when treated with the arsenicals.

As no late case of this specific type of bone yaws has been seen, spontaneous healing cannot be excluded. However, it is more likely that, untreated, it would run its course, and, as the patient's resistance increased, the bone would heal by sclerosing, and what is called "chronic" yaws would result.

JOINTS AND TENDON SHEATHS

The disease tends to attack joints and tendon sheaths (tendon sheaths, perhaps, more often than joints). It is common to find a patient with ganglia involving the dorsal tendons of both wrists or the dorsal tendons of both feet. Sometimes, all four extremities are simultaneously involved.

Less frequently, compound palmar ganglia or tenosynovitis of the peroneal tendons is seen. The African complains that the swellings ache and interfere with his work. On examination, the swellings are tense and mildly tender, and may give the impression of containing "melon-seed" bodies. At operation, the swelling is found to consist of oedematous granulation tissue involving the lining of the sheath, and attached to the tendon itself, often eroding it. The impression of "melon-seed" bodies is conveyed by hypertrophied villous tags of fat. The microscopic picture is similar to that in bone lesions.

FIG. 11

Case 11. Acute yaws of the femur in an African soldier. The roentgenographic appearance and clinical picture were similar to, but milder than those of the patient shown in Figs. 10-B and 10-C.

In joints, the disease produces a chronic and increasing synovitis, which is relatively painless. The author has seen no case in which the cartilage of the joint has been diseased. At operation a thick oedematous synovial membrane is found. In the knee joint, in addition, the villi of the suprapatellar pouch are hypertrophied. Occasionally dark granulations invade the synovial membrane. This hypertrophied synovial membrane is well shown in microscopic section. The endothelial layer is three or four cells thick instead of one, and there is a subjacent round-cell infiltration with no obliteration of the blood vessels (See Figure 9).

TREATMENT

When treated with arsenicals, the symptoms accompanying these swellings of joints and tendon sheaths rapidly disappear, but the swellings themselves subside very slowly. It may be that the disease has injured the absorptive capacity of the membranes.

It is our practice, therefore, to excise the ganglia the day after the patient is admitted to the Hospital. He is allowed to return to his Unit, when the sutures have been removed. Arsenicals are given the day after the operation, and this treatment is continued by the Unit Medical Officer.

As trauma appears to decide the site of the disease, it is not surprising to find that a torn meniscus may be accompanied by inflammation of the synovial membrane of the knee joint. This is recognized at operation by the thick oedematous nature of the synovial membrane. A course of antiyaws treatment should then be started a day or two after removal of the meniscus. In some cases, in spite of the double pathology, the patient does well, but, in three of eight such cases, the results were not good, for, although full movement and good muscle tone were recovered, the patient complained of persistent and "nagging" pain. There were no objective signs, and it could not be determined whether or not the pain was genuine. The patients were given the benefit of the doubt, and disposed of accordingly. Two of the eight patients were African civilians in congenial employment, and both recovered in record time.

FIG. 12

Case 12. Acute yaws of the humerus in an African soldier. The history and symptoms were similar to, but not so severe as those of the patient shown in Figs. 4-A, 4-B, and 4-C.

RESPONSE TO TREATMENT

The response to treatment is dramatic. Within a week or two the patient has lost his pain and recovered his sense of well-being. Tenderness disappears soon afterward, but the actual tumors subside slowly. Roentgenographic evidence of consolidation of the lesion can be demonstrated within six weeks (See Figures 4-B, 4-C, 8-B, and 8-F). The author used acetylarsan or novarsenobillon (N.A.B.), or alternate doses of bismostab and sulphostab,—all with good effect.

SUMMARY

An acute disease of bone is described. It is of interest to students of bone pathology because, in the same disease, periosteal new bone may be laid down in "onion-layers" or in radiating spicules. It appears to "onion-layer" in the most rapidly progressive type. Further study may give us, by analogy, an index of the comparative rate of growth of osteogenic sarcomata.

Note: The author would like to express his gratitude to Colonel L. A. Harwood, T.D., Brigadier F. A. R. Stammers, Captain A. N. McGill, and Captain H. A. McCaffery, all, in 1942, of the 34th General Hospital, and to Mr. Quinton Stewart, F.R.C.S., Senior Surgeon, the Sierra Leone Government, for making it possible to collect and correlate the clinical material; and to Lieutenant Colonel Brian Maegraith and Wing-Commander Cecil J. Hackett for their advice and help with the pathology. The author would also like to thank Mr. S. J. Smith of the Connaught Hospital, Freetown, and Sergeant Collis, R.A.M.C., for the roentgenograms.

REFERENCES

1. HACKETT, C. J.: Boomerang Leg and Yaws in Australian Aborigines. Royal Soc. Trop. Med. and Hygiene, 1936.
2. HACKETT, C. J.: Personal communication.
3. STANNUS, H. S.: Yaws. *In* H. Rolleston's British Encyclopaedia Med. Practice, XII, 631, 1939.
4. STANNUS, H. S.: Yaws and Syphilis: A Critical Review. Tropical Diseases Bull., XXIII, pp. 1 and 81, 1926.

CONGENITAL TALONAVICULAR SYNOSTOSIS

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In the October 1943 issue of *The Journal of Bone and Joint Surgery*, O'Donoghue and Sell reported a case of bilateral symmetrical talonavicular synostosis. These authors made a thorough and most interesting review of the literature, and stated, regarding their patient, "This case is unusual, because the synostosis is bilaterally symmetrical. This is only the second instance in which it has been reported, and the first occasion where it has been substantiated with roentgenograms." Credit for reporting the first talonavicular synostosis is given to Anderson, who recorded the other bilateral case in 1879. In reviewing the literature, O'Donoghue and Sell also found reports of five cases of unilateral talonavicular fusions; four of these patients had other associated abnormalities. From their paper, one must conclude that talonavicular synostosis is either an unusual condition, or that it has not been considered of sufficient importance to warrant reporting. Four patients with talonavicular synostosis have been seen at the Clinic.

CASE REPORTS

CASE 1. W. J. C., No. 44851, a white girl, aged ten, was first seen in the Clinic on October 12, 1938. At that time she had a bony enlargement over the medial extremity of each tarsal navicular. These bony protuberances "pressed" against her shoes. She also had slight "tiredness" after excessive weight-bearing. The appearance of the feet before operation is shown in Figure 1.

Roentgenograms taken at the Baptist Memorial Hospital were reported by the roentgenologist, Dr. J. E. Whiteleather, as follows: "The navicular bones are fused to the astragali in both feet. There is a rounded protuberance projecting medially from the distal end of the combined bones".

On October 14, 1938, both feet were operated upon and the excess bone at the medial ends of the navicular portions of the combined bones was removed. At operation there was no vestige of a joint between the medial end of the navicular and the neck of the talus. The posterior tibial tendon was found in its normal location, and did not insert into the medial end of the navicular, as seen in a prehallux foot.[2] The patient had an uneventful recovery and obtained a good cosmetic result.

FIG. 1

Case 1. Appearance of the feet before operation. Note the rounded eminences over the medial aspects of the navicular portions of the combined bones. The arches are of average height. The external appearance of the feet is not that of the prehallux type of congenital flaccid pes planus.

CASE 2. M. J. G., No. 58378, a white boy, aged ten, was first seen in the Clinic on January 4, 1943. His chief complaint was moderate pain beneath the longitudinal arches, and bony enlargements over the medial ends of the naviculars. Roentgenograms (Figs. 2-A and 2-B) showed bilateral talonavicular synostosis, with bony enlargements at the medial ends of the navicular portions of the combined bones. The patient's symptoms were probably due to foot strain, and may or may not have been related to the congenital anomaly. His symptoms were partially relieved by the

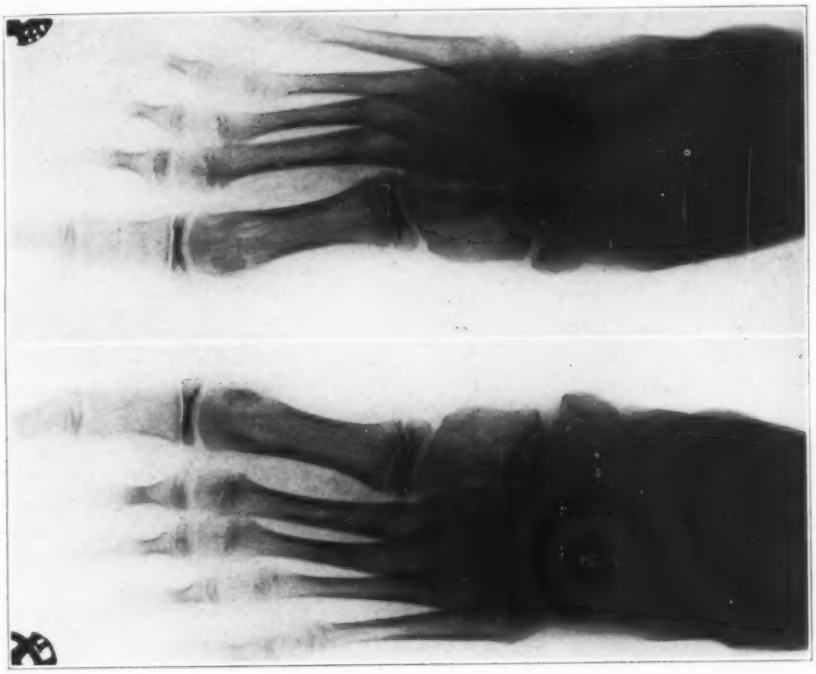

FIG. 2-B

Anteroposterior roentgenograms of both feet. Note the rounded eminences at the medial ends of the navicular portions of the combined bones. This eminence resembles a prehallux on the right side and is not fused to the navicular.

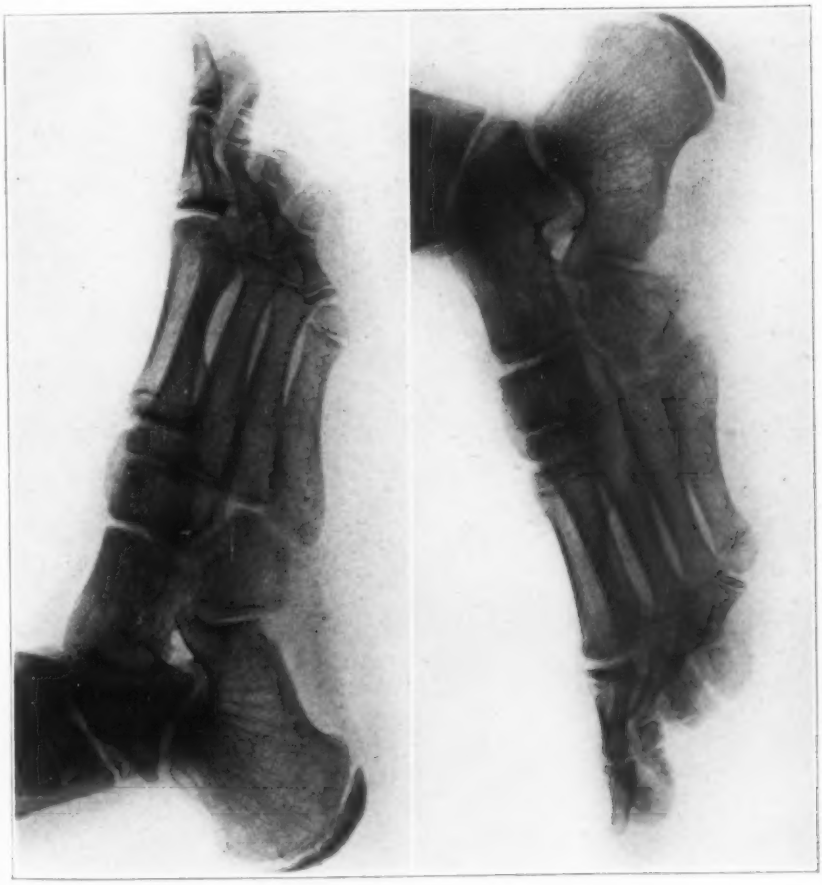

FIG. 2-A

Case 2. Lateral roentgenograms, showing bilateral congenital synostosis between the talus and the navicular.

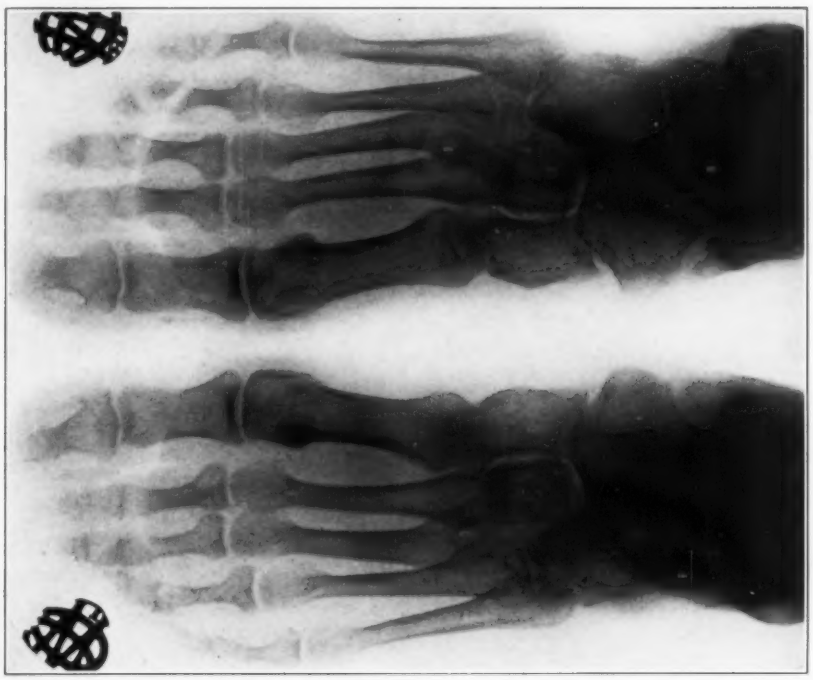

FIG. 3-B

Anteroposterior roentgenograms of both feet. Note the rounded eminences over the medial aspects of the navicular portions of the combined bones.

FIG. 3-A

Case 3. Lateral roentgenograms, showing bilateral congenital synostosis between the talus and the navicular.

talus and the navicular.

eminences over the medial aspects of the navicular portions of the combined bones.

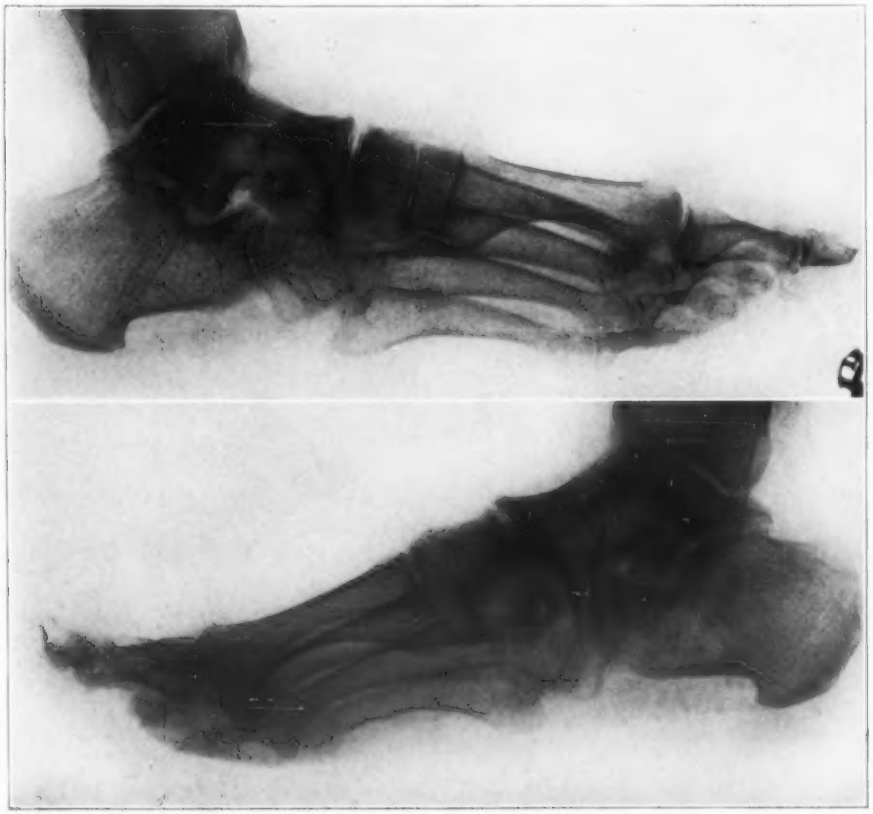

FIG. 4-A

Case 4. Lateral roentgenograms, showing bilateral congenital synostosis between the talus and the navicular. Note arthritic changes between the navicular portions of the combined bones and the cuneiform bones.

FIG. 4-B

Anteroposterior roentgenograms of both feet. Note the rounded eminences over the medial aspects of the navicular portions of the combined bones.

use of arch supports of leather and cork. On a subsequent visit to secure new arch supports, he stated that his father had a "double ankle bone, too". Accordingly, the father was requested to report for examination.

CASE 3. L. G., No. 61832, a white man, aged forty-five, father of this boy (Case 2), came to the Clinic at our request on December 28, 1943. He had no complaints referable to his feet, except the abnormality due to the bony enlargements over the medial sides of the naviculars. Roentgenograms showed bilateral talonavicular synostosis, with bony enlargements over the medial ends of the navicular portions of the combined bones (Figs. 3-A and 3-B). While this patient was being examined, his son (Case 2) suggested that his paternal grandmother had similar feet. She also was requested to report for examination.

CASE 4. F. I. G., No. 61951, a white woman, aged seventy-two, grandmother of the boy (Case 2), came to the Clinic at our request. The patient stated that she had had no pain in her feet until she was forty years of age, but that she had later noted gradually increasing pain. This could probably be accounted for by arthritic changes and impaired circulation. Roentgenograms showed bilateral talonavicular synostosis, with bony enlargements over the medial ends of the navicular portions of the combined bones (Figs. 4-A and 4-B).

These four patients all had similar bilateral congenital talonavicular synostoses. In addition, each had a definite bony enlargement over the medial end of the navicular portion of the fused navicular and talus. This enlargement was the one constant feature recognized by each of the four patients before coming to the Clinic.

Congenital talonavicular synostosis is an interesting anomaly, but is probably of little clinical importance. The absence of the talonavicular joint should not weaken the foot. In all four patients, the arches were of average or above-average height. In Case 1, the patient was primarily interested in the appearance of the feet, and in securing better-fitting shoes. In Case 2, the symptoms of foot strain were mild. In cases 3 and 4, the patients were examined at the request of the author. The patient referred to in Case 3 was not having any difficulty with his feet. The patient referred to in Case 4 had noted gradually increasing pain in her feet since the age of forty. Roentgenograms of her feet show definite arthritic changes between the navicular portions of the combined bones and the cuneiform bones. The absence of a talonavicular joint produces an increased strain on the joint between the combined bones and the cuneiforms. This excess strain may have predisposed to the arthritic changes.

The relationship of the patients referred to in Cases 2, 3, and 4 suggests the possible hereditary nature of the condition.

REFERENCES

1. Anderson, R. J.: The Presence of an Astragalo-Scaphoid Bone in Man. J. Anat. and Physiol., XIV, 452, 1879.
2. KIDNER, F. C.: The Prehallux (Accessory Scaphoid) in Its Relation to Flat-Foot. J. Bone and Joint Surg., XI, 831, Oct. 1929.
3. O'DONOGHUE, D. H., AND SELL, L. S.: Congenital Talonavicular Synostosis. J. Bone and Joint Surg., XXV, 925, Oct. 1943.

POSTERIOR APPROACH TO THE FEMUR *

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

Although many surgeons have doubtless operated upon the middle three fifths of the femur through a posterior approach, our attention was first called to this means of access while doing a neurolysis of branches of the sciatic nerve to the posterior thigh muscles for spastic hemiplegia. Perhaps familiarity with the operation upon the branches of the sciatic nerve for such conditions gave us a sense of security, not generally enjoyed while working close to this nerve. During the procedure, it was found that the dissection exposed the attachment of the thigh muscles to the linea aspera, and that exposure of the femur posteriorly was extremely simple, rapid, and free from laceration or division of muscle tissue. It was also noted that the sciatic nerve remained imbedded in fat and in the fascial septum covering the medial wall of the section, unless definitely dissected and freed by the surgeon.

From the standpoint of this approach, the only structure obscuring the middle three fifths of the femur is the long head of the biceps. This is retracted laterally or medially, depending upon the level to be exposed (Figs. 1-A and 1-B). When the intact long head of the biceps is retracted medially, the upper portion of the middle three fifths is widely exposed; when this structure is retracted laterally, the lower portion is exposed. Medial retraction affords protection to the sciatic nerve; lateral retraction results in considerable exposure of this nerve. In heavily muscled patients and in those requiring exposure of the entire middle three fifths of the bone, it is necessary to divide the lower expansion of the long head of the biceps and to retract this muscle, with the sciatic nerve, medialward (Fig. 1-C). Such retraction does not injure the blood or nerve supply to the long head, and greatly facilitates the exposure. Resuture can be readily accomplished at the completion of the work on the bone. No instance of damage to the nerve, left in its bed, has been noted as a result of retraction. In fact, no case has been noted in which retraction has caused muscle contractures below the point of retraction due to irritation of the sciatic nerve, even at time of operation. Experience with neurolysis of branches of the sciatic nerve to the thigh muscles showed that extensive division of the nerve supply was necessary to weaken appreciably the musculature in this region. Therefore, occasional aberrant branches from the sciatic nerve to the muscle have been sectioned in approaching the femur in this manner, without noticeably altering function following operation. Most of the nerves to the hamstrings leave the sciatic trunk well above the operative field, and difficulty in avoiding injury to them is generally not encountered in the dissection.

OPERATION

A posterior mid-line incision is made, extending down to the upper corner of the popliteal space, and is carried through the skin and fascia. It may be necessary to extend the incision to the gluteal fold (Fig. 2,*A*). By blunt dissection with the index fingers at the middle of the thigh, the posterior surface of the femur can be palpated. By retraction with the fingers, the middle three fifths of the linea aspera, covered by the attachment of the vastus lateralis and vastus medialis, can be exposed. In case it is desired to expose the upper portion of the femur, the dissecting fingers should be placed lateral to the long head of the biceps. If the lower portion of the femur is to be seen, the dissecting fingers should be placed medial to the long head of the biceps. If all of the posterior three fifths of the femur is to be exposed, the dissection should be made to the linea aspera, entirely lateral to the long head of the biceps. After the lower expansion of the head of the biceps has been

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 1, 1944.

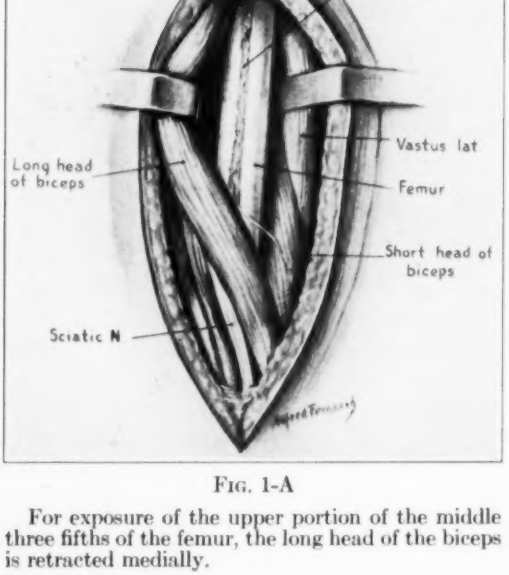

FIG. 1-A

For exposure of the upper portion of the middle three fifths of the femur, the long head of the biceps is retracted medially.

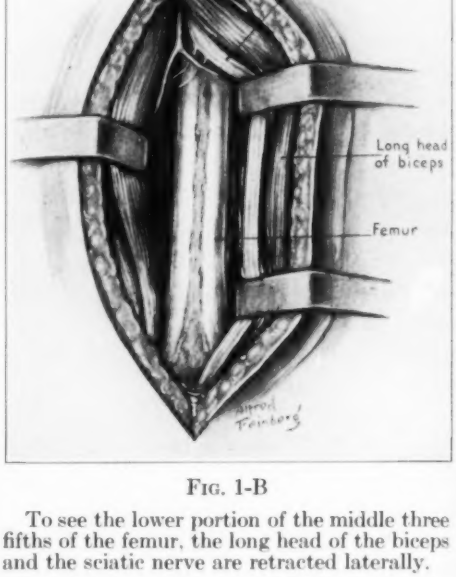

FIG. 1-B

To see the lower portion of the middle three fifths of the femur, the long head of the biceps and the sciatic nerve are retracted laterally.

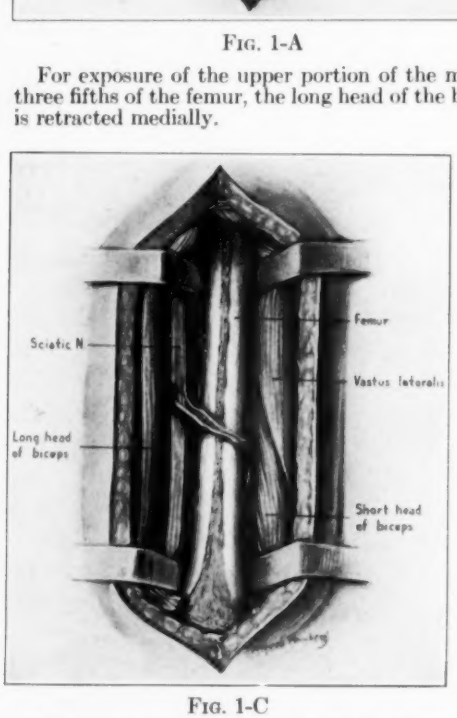

FIG. 1-C

For complete exposure of the middle three fifths of the femur, the lower attachment of the long head of the biceps is divided, and, with the sciatic nerve, is retracted medially.

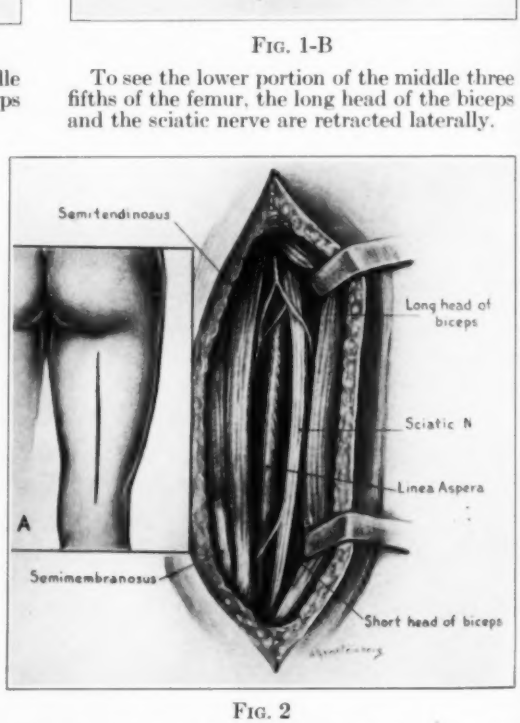

FIG. 2

The entire middle three fifths should never be exposed by lateral retraction of the biceps, as the sciatic nerve will be left exposed to damage.

Insert *A*: Line of incision for exposure.

divided, it may easily be displaced medially, and a wide exposure of bone may be obtained. The branch of the sciatic nerve to the short head of the biceps may then be observed as it crosses the central portion of the femur. This branch may be saved or divided. If the long head of the biceps is divided, sutures should be placed in the tendinous stubs to facilitate reattachment of the divided ends at the close of the operation.

Complete exposure of the middle three fifths of the femur by lateral retraction of the long head of the biceps (Fig. 2) should *never* be attempted, since this may subject the sciatic nerve to damage and place it under traction.

Therefore, it is apparent that the long head of the biceps is the important guide to safety in this approach.

For upper exposure, it should be retracted *medially* (Fig. 1-A).

For lower exposure, it should be retracted *laterally* (Fig. 1-B).

For complete exposure, it should be retracted *medially* and its *distal end divided* (Fig. 1-C).

The muscle attachments to the linea aspera are then freed by sharp dissection, completing the exposure of the bone. The only bleeding of any extent will be encountered at this time, and can readily be controlled. Subperiosteal dissection of the whole femoral shaft in its middle three fifths is thereafter extremely easy. Such reconstructive work as may be necessary can then be carried out. In the occasional instance where the long head of the biceps has been divided, reattachment of the ends is secured. Closure of the wound is completed by suture of the skin alone, as all other structures fall back into place with closure of the integument. A second operation through the same incision has been done, and remarkably little fibrosis has been encountered.

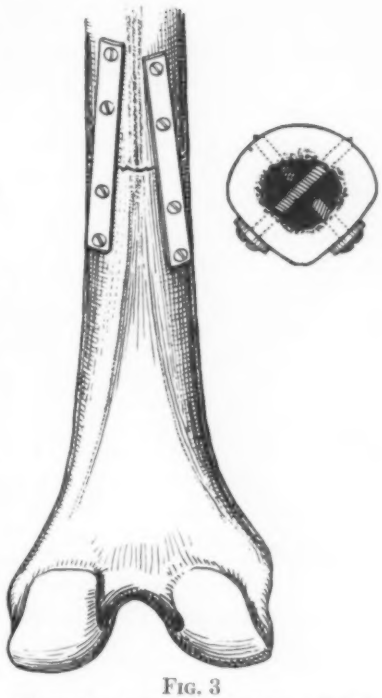

FIG. 3

Through a posterior exposure, application of two plates to a fracture is simple. The plates, lying at right angles, provide greater strength and stability. Scarring of muscle is avoided.

INDICATIONS

This approach has been used for the following:

1. Most frequently, for fractures of the middle three fifths of the femur, including open reduction and operation for malunion and non-union. The approach has been uniformly satisfactory in all such cases, and has avoided the profuse bleeding and muscle-scar contractures and adhesions previously encountered in lateral or other incisions.

2. For biopsy of the femur in this region. This method is rapid, non-traumatic, and particularly free from hemorrhage or shock.

3. For the removal of discrete benign lesions, such as osteoid osteoma, or decortication of this area of the femur in sclerosing lesions. Excellent exposure is provided, without the sequelae incident to division of muscle tissue by any other approach.

4. For femoral shortening to equalize leg length. (The author does not approve of this, but carried out the procedure in one case.)

CONTRA-INDICATIONS

The posterior approach, as described, is contra-indicated in dealing with osteomyelitis of the femoral shaft. Draining sinuses, forming in the incisional wound, would probably result in more or less involvement of the sciatic nerve in a fair percentage of instances. While no untoward results, as far as the sciatic nerve is concerned, have been seen in the author's cases, in one wound which became infected, the possibility of this complication was a source of anxiety. In these cases of osteomyelitis, we prefer to approach the lesion through a lateral incision, even though we know that muscle adhesions and scarring will probably limit knee flexion and will weaken extension.

ADVANTAGES OF THE POSTERIOR APPROACH

1. The middle three fifths of the femur may be exposed with ease.

2. The amount of bleeding is very much less than that incident to approaches which transect the muscles.

3. Exposure may be made through a single incision adequate to the application of two bone plates at right angles to each other (Fig. 3).

4. The incision eliminates muscle scars or adhesions which may limit the motion or decrease the strength of the knee.

Ever present is the danger of injury to the sciatic nerve. Because such damage has not been observed, does not mean that injury to this structure may not be caused by rough retraction, undue dissection, or exposure. Although the nerve itself may not be seen, its exact location must be determined and constantly borne in mind, and as much gentleness as possible must be exercised throughout the procedure.

DISCUSSION

Dr. J. S. Speed, Memphis, Tennessee: Dr. Bosworth's paper has brought to us a very satisfactory addition to our present means of access to the femur.

Proper surgical approach is one of the most neglected subjects in orthopaedic surgery. Each of the present standard approaches to the femur has certain advantages and disadvantages. The *lateral approach*, the one most frequently used, is inadequate for an extensive reconstruction of the femur, because of the difficulty in retracting the tissues. It is still adequate for all cases in which drainage is expected. The *anterolateral approach* is ideal when there is to be no drainage, but it is not adequate for drainage. It permits one to look directly down on the bone and to obtain adequate exposure. The one objection is that it requires a certain amount of muscle splitting, associated with which there is hemorrhage, negligible in many cases but in large amount in some. This can be adequately controlled, and it is usually not a serious objection.

As far as anaesthesia is concerned, I think you must concede that in the approach to the femur particularly, but in any surgical procedure where the patient's general condition is of some concern, a general anaesthetic, administered while the patient is on his back, is more easily controlled and more satisfactorily watched. I have a safer feeling when the patient is on his back than when he is prone. This is an objection to the posterior approach.

From an anatomical standpoint, the *posterior approach* has certain advantages. It is developed along a fascial plane; it does not require muscle splitting; it is free from hemorrhage; and it allows the operator to work with the field directly below his eyes, as in the anterior approach. However, in this approach, I do not think we can get away from the danger or possible danger of injury to the sciatic nerve. It is perfectly true that, when this incision is performed properly, and when adequate care is taken to protect the main trunk of the sciatic nerve—the branches are of relatively little significance—it is difficult to paralyze the hamstring muscles. In those cases in which the main trunk of the sciatic nerve must be retracted out of the operative field, it must be constantly watched by the surgeon, which is a definite objection to this approach. In a large number of major reconstructive procedures on the femur, the surgeon is under stress, and where bone grafts are being used, his mind must be concerned with the fracture and not with his assistants. For tumors on the back of the femur, or lesions other than inflammatory, which lie on the posterior surface of the femur, the approach described by Dr. Bosworth is ideal. I wish to congratulate him on emphasizing this approach.

In summary, the anteromedial incision would be my choice for cases requiring large reconstructive procedures which do not necessitate drainage; the lateral approach in those cases which require drainage; and the posterior approach for lesions situated chiefly on the posterior surface of the femur.

Dr. J. Albert Key, St. Louis, Missouri: I think this is an adequate approach for tumors, but when we are going to repair fractures, we are in danger of spoiling everything we have done by turning the patient on his back to apply the external fixation. The critical point in my own cases is the time between the operation and the completion of the external fixation. This is because I use a minimum of internal fixation.

Dr. David M. Bosworth, New York, N. Y. (closing): In reducing fractures of the femur, one can expose the whole middle three fifths of the femur (and a little bit more) without any traction on the nerve. The point of traction will be on the fibrous raphe along the insertion of the vastus medialis. This fibrous raphe when intact is so tight that one cannot possibly put any great pressure on the sciatic nerve. In fractures where one has to rotate the fragments with bone-holding forceps, one should be sure, before placing the forceps, that the nerve is not in the way. With forceps, one can rotate the fragments; turn one surface up, and put the plate on; then turn the other surface up, and apply the second plate. During exposure, both ends of the femur can be drawn back out of the wound, since, with the patient on his face, the hip and knee joints permit this mobility. After the fixation is in place, one need not worry about turning the patient over and putting on a cast. If good fixation has been obtained with two plates, the patient can even be returned to bed with light traction.

There is very little bleeding. After the linea aspera has been exposed and sponged, the circumflex vessels stand out plainly and may be ligated and divided. Considering the numerous operative procedures (especially spine fusion) done without difficulty with the patient on the abdomen, there is no need to fear the anaesthetic with the patient in that position.

OLD DISLOCATION OF THE ELBOW

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CÓRDOBA, ARGENTINE REPUBLIC

The authors have had occasion to observe numerous cases of dislocation of the elbow in children and adolescents, and less frequently in adults. The majority of these cases were pure dislocations, but, with relative frequency, were accompanied by fractures of the medial epicondyle, of the tip of the coronoid process, of the head of the radius, or of the lateral condyle. If the reduction is done soon after the trauma, it is comparatively easy; and, if proper manipulation is used, damage is reduced to a minimum, so that stiffness after the reduction is lessened.

Many times the dislocation passes unobserved. In one of our cases, the child had a fracture of the forearm in the lower third. The physician who had first treated the patient reduced the fracture, which was the more apparent, and fitted a plaster-of-Paris cast to the arm, ignoring the existence of the dislocation. In other cases, the patients or their parents had given little importance to the accident when it occurred, and the patients were treated by a bone-setter who, after pulling the arm about, placed it in a splint in full extension. Some of the patients lived far away from populated centers, and had not been treated for the injury until many days after the accident, when they found that the elbow had no movement and the patient came for treatment.

If a dislocation of the elbow is not reduced immediately, definite changes take place in the articular surfaces and periarticular tissues after fifteen or twenty days, which make the dislocation impossible to reduce manually. According to Lec`ne and Huet, "The dislocation gets old very quickly . . ."

Authors differ in opinion with regard to the period during which manual reduction is possible. Hennequin cites cases where reduction was done eight months after the dislocation; Richard and Nélaton, 140 and 145 days after; Denucé, Malgaigne, and others, four or five months after; and Quenu, Boyer, Cooper, and others, a month and a half after injury.

Today, knowing the possibility of osteoma formation and the consequent stiffness of the elbow following trauma, especially in children, we think that such late reductions must have resulted in ankylosis, at best in a good position. In our operations upon patients seen twenty days after the dislocation, we have observed closely the osseous and fibrous changes, and we think it correct to say, with Dollinger, that a dislocation which has not been reduced twenty-one days after the accident cannot be reduced satisfactorily by manual reduction. We would add that the time is even less in children, in whom manipulation for attempted reduction has proved fruitless, or where treatment has included immobilization or massage.

During the past ten years, we have seen thirty-five cases of old dislocation of the elbow, and have used a more or less standardized treatment in all of them. The results in these cases may be of interest.

The ages of our patients ranged from three seen at six years of age to one seen at fifty-one years of age. All but four were under fourteen. The incidence was twenty-eight male, and seven female. The time which had elapsed between the dislocation and the consultation with us varied between twenty days and five months; the majority of the patients were seen within thirty to ninety days. Fractures associated with the dislocation were found frequently,—of the medial epicondyle in eight cases, of the tip of the coronoid process in three, of the lateral epicondyle in one, and of the lateral condyle in one. A

fractured head of the radius, which has been seen in recent cases, has never been found in old dislocations.

Clinically, most of the cases presented a complete posterior or posterolateral displacement of the bones of the forearm, at an angle which varied between 130 and 170 degrees of extension. In children who had not received treatment, there was more movement of the joint, but complete ankylosis occurred in two cases in which forced massage had been used. In two of our patients who had flexion of 130 degrees, the forearm was in marked pronation and could not be supinated; but in those cases where the dislocation was directly anteroposterior, and where the arm was in complete extension, there was normal pronation and supination. The flexion-extension movement, in general, was not more than 20 degrees.

Roentgenographic examination gave constant evidence of a radiohumeral "horn", which was produced by the ossification of the hematoma found between the periosteum adhering to the capsule near the head of the radius and the humerus displaced forward and medially (Figs. 5-A and 5-B). Less frequently, ossification of the anterior surface of the capsule has been observed, and forms the "anterior slab" of Delbet (Fig. 8-A). In some cases, we have seen ossification both in front of and behind the capsule.

The anatomicopathological findings during the operations have been the following:

1. *Ossification.* In the same manner that ossification occurs in supracondylar fractures between the periosteum and the posterior aspect of the humeral diaphysis, so also, in a dislocation which is not reduced, a rapidly formed ossification is often seen between the periosteum, which is joined to the capsule and the radial collateral ligament, and the inferior extremity of the humerus, which has torn the capsule at its medial aspect and has been displaced in front of and medial to the forearm bones. This is sometimes evident in roentgenographic examination (Figs. 2-A and 2-B).

Frequently also an ossification of the anterior part of the capsule is found, which may be mistaken for an osteoma of the brachialis, and which constitutes the "anterior slab" of Delbet (Fig. 8-A).

Of less importance are small ossifications which are found on the medial aspect, near the medial epicondyle that has been fractured and displaced below the trochlea.

2. *Scar Tissue (Fibrous).* This is formed at the time of and after the ossification, but sometimes it is found only two or three months after the dislocation. It fills the olecranon fossa in the part where there has not been ossification, and completely fills the greater sigmoid cavity of the ulna, so that the articular cartilage cannot be seen. At the inferior extremity of the humerus, the cartilage surface is covered also in most of its extent by a thin layer of fibrous tissue.

3. *Retraction of the Soft Parts.* This is very evident in the triceps, when the arm has been immobilized in extension, or when the reduction has been done late. This retraction makes suture of the wound considerably more difficult, to the extent that some surgeons, Van Gorder among them, use grafts of fascia lata or of the tendo achillis to join the separated ends, after the joint has been reduced.

In all of our patients who were operated upon, the dislocations were not more than five months old, and the articular surfaces had not undergone changes, with the exception of the fractures which some presented. After six months to a year, important changes occur in the articular surfaces. For this reason, operative reduction is not advisable; arthroplasty of the elbow is preferable. In all our cases of old dislocations of the elbow, the treatment has been surgical. The incision of the skin has varied, but we have always performed an arthrotomy, splitting the triceps tendon, and incising the soft parts behind the joint. In only two cases have we fractured the olecranon at its base.

The only serious complication in these cases was a suppuration of the wound, in a child who had some time previously suffered from impetigo. The operation was lengthy and drawn out, and the final result was a bony ankylosis of the elbow in a good position (angulation of 100 degrees).

Nerve complications have been temporary in six cases. In five cases, paralysis of the ulnar nerve, due to an Esmarch bandage, occurred. In one case (Case 5), we found the median nerve displaced to the posterior and medial aspect of the humerus; it was contused during the reduction, with a resulting partial paralysis of the nerve. Impaired flexion movement of the index finger and opposition of the thumb resulted, but without grave sensory or trophic changes. Six months after the operation, the function of the hand was nearly normal, and the patient had only slight difficulty in flexing the index finger without using the rest of the fingers.

Operative reduction was accomplished in all cases with comparative ease, even in those in which, as observed in Figures 6-A, 6-B, 6-C, and 6-D, there was also a fracture of the lateral epicondyle. The fracture was reduced at the same time as the dislocation, and a very satisfactory result was obtained.

Functional results have been, in general, good; but end results cannot be reported, because in only fourteen of our cases have we been able to follow them for more than a year after the operation. In all of them, the elbow was stable and painless, with movement that varied between 40 and 120 degrees. In our first cases, we have observed, in follow-up examinations, that flexion was complete but extension limited, due to the fact that we practised immobilization at a right angle, to secure stable reduction, and through fear of postoperative ankylosis (Figs. 7-E and 7-F, patient ten years after the operation). In these cases, reconstruction of the triceps was necessary to keep the elbow flexed. In some, the procedure has left an evident weakness of the triceps, but in others it has produced little functional defect.

In more recent cases, we have followed the advice of Tavernier and Pouzet, and have immobilized the elbow at the beginning, at an angle of 160 degrees, which permits a much better reconstruction of the triceps tendon, and allows a far superior functional result with regard to the extension of the forearm.

However, constant observation of these patients is necessary, because the reduction is unstable. In two of our cases, the dislocation recurred after the operation, while the cast was being applied, and we had to make a new cast, after a second reduction of the dislocation and fixation of the elbow at a right angle.

TREATMENT

In all our cases, we have practised systematically operative reduction of the dislocation, but, before describing our technique, we consider it of interest to review the methods which have been proposed by different authors.

Manipulative Methods

Farabeuf recommended, in dislocations less than four or five months old, the use of strong traction by flexing and extending the arm, and then pronating and supinating it, with the object of breaking down adhesions and facilitating later manipulative reduction. Broca wrote that he had failed when he used Farabeuf's method in dislocations more than forty-five days old, and did not favor forcible manipulation in such cases. Watson-Jones recommended in some cases the use of Thomas's "sham" reduction, which consists in flexing the elbow at a right angle and keeping it so in a sling for three weeks, after which the patient forms a nearthrosis by active movement.

Operative Methods

Excision. This is the first method which was used as a surgical treatment for old dislocations, and was very highly recommended by Ollier. Nové-Josserand, referring to his experience in these cases, reaches the following conclusions:

1. In children, it is necessary to make extensive excisions. (He obtained a good result in a total excision in which he removed nine centimeters of osseous surface.)

2. With a hemi-excision, a satisfactory result is obtained only if five or six centimeters of bone has been removed and fibrous tissue has been interposed,—that is to say, only when an arthrotomy has been performed.

3. In children, the possibility of a loose elbow does not exist. (Ollier feared this result in adults.)

4. The best results obtained with regard to movement of the joint, followed complete excisions.

5. In general, after the excision, the affected arm has less function than the other.

Arthroplasty. This is a method that has given very good results in adult patients where the dislocation was old, and where the articular surfaces had suffered anatomical changes, due to the time elapsed, making operative reduction inadvisable. Putti refers to numerous cases of old dislocations, in which an arthroplasty was performed with very good results. He always used the posterolateral approach of Kocher, and another small incision on the medial side to protect the ulnar nerve.

Serra used a "goblet" incision, and followed the same procedure that he had used in the knee.

Operative reduction is the only treatment which should be chosen for patients in whom the dislocation is a few months old.

METHOD OF APPROACH

The arthrotomy can be done by different approaches, of which we will consider only the posterolateral approach of Kocher, the transolecranal approach, and the transtendinous approach.

Posterolateral Approach

To avoid injury to the extensor structures of the forearm, Kocher suggested access to the joint by a lateral route which passes between the triceps and the extensor carpi radialis. Dollinger used Kocher's approach, and also a small secondary medial incision to protect the ulnar nerve, in a manner similar to Putti's. When the triceps has been shortened as a result of trauma and immobilization, this approach is not favorable to the reduction. Dollinger succeeded in only twenty cases out of thirty-four, and had to perform a hemi-excision in the remaining fourteen. Of these

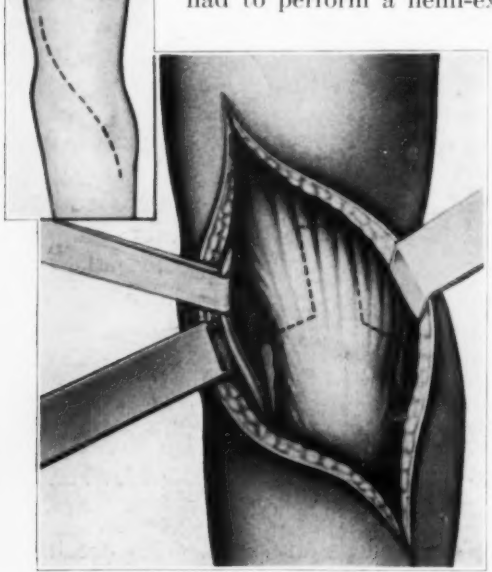

FIG. 1-A

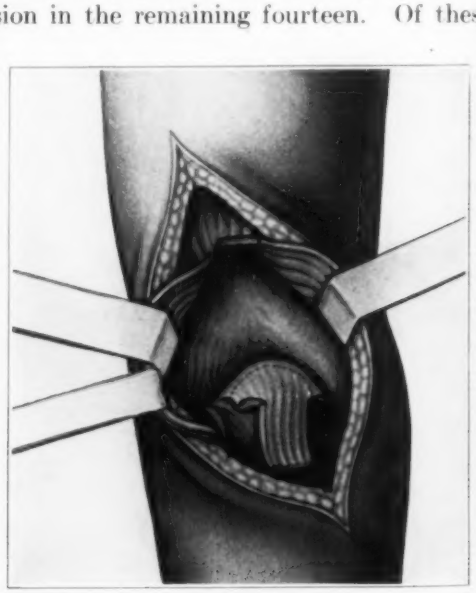

FIG. 1-B

FIG. 1-C

FIG. 1-D

Operative steps showing reduction of old dislocation of the elbow.

Fig. 1-A: Skin incision. Freeing the ulnar nerve with incision of the superior fibers of the flexor carpi ulnaris. Dotted line indicates incision of the triceps tendon.

Fig. 1-B: Opening of the olecranon fossa. Exposure of the articulation is on dotted line.

Fig. 1-C: Extirpation of the radio-humeral "horn" and all other areas of ossification that are around the lower humeral extremity.

Fig. 1-D: Removal of all fibrous tissue that fills the greater sigmoid cavity.

Fig. 1-E: After reduction of the dislocation, the triceps tendon is sutured.

Fig. 1-F: The same skin incision is used for the transolecranal approach. Deeper incisions are made at the sides of the triceps tendon, and the base of the olecranon is fractured.

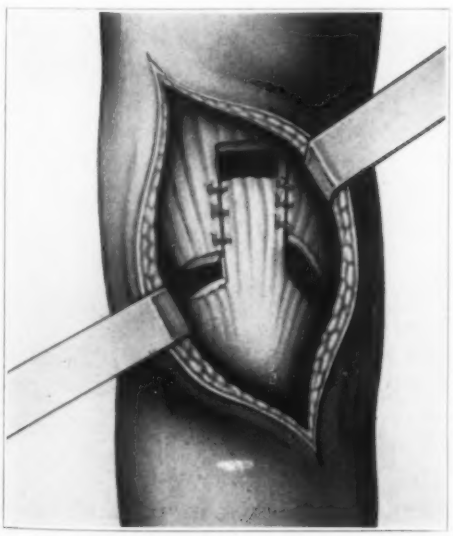

FIG. 1-E

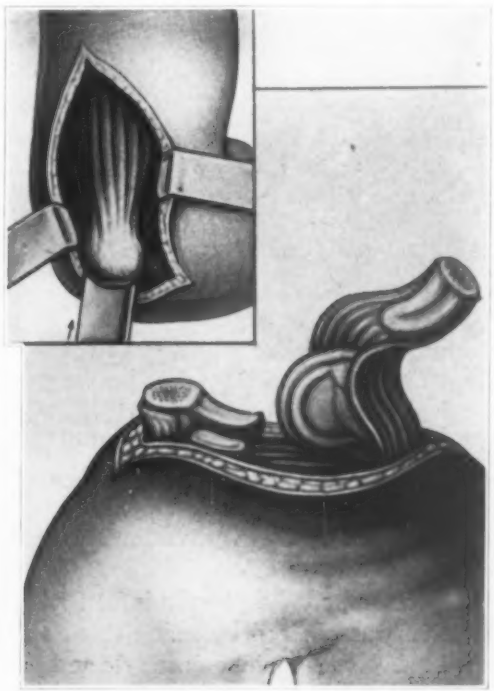

FIG. 1-F

FIG. 2-A

FIG. 2-B

Case 2. Anteroposterior and lateral roentgenograms taken before operation, and showing extreme ossification and the posterolateral "horn", ninety-five days after injury.

twenty cases, twelve were followed for a long time; in nine of them, there was considerable movement, but in three, ankylosis had taken place. Of the fourteen cases in which excision of the inferior humeral epiphysis was performed, eleven were seen two to seven years after the operation; five showed considerable movement, and six, complete ankylosis. Dollinger concluded, after reviewing his final results, that operative reduction is far superior to excision. One of our colleagues, Bertola, also recommends a modified Kocher approach to the elbow.

In general, according to our experience in these cases in which an excision or arthroplasty is to be performed, the lateral approach, without sacrifice of the extensor structures, is the best. However, in dislocations with marked displacement, and consequent shortening of the triceps, this approach would make reduction difficult or even impossible. If reduction were obtained, it would be only after considerable trauma to the articular surfaces, and with a less favorable final functional result.

Transolecranal Approach

The joint can be approached by fracturing the base of the olecranon perpendicularly, as recommended by Alglave, Lexer, MacAusland, and others, or obliquely, as used by Albee for arthrodesis, and by Goñi Moreno. We have used this approach in only two cases. The operation proved to be very easy; vitallium screws were used, and the postoperative course was entirely normal.

The case illustrated by Figures 6-C and 6-D demonstrates the success of this method. The patient was a child, twelve years of age, who had fallen from a horse forty days before. His forearm was in extension, with only 10 degrees of flexion-extension movement; the pronation and supination movements were slightly limited. The transolecranal approach was used in this operation.

The lateral condyle (capitulum) was retracted outward to preserve its blood supply. Reduction was effected by fixing this condyle with a vitallium screw (Fig. 6-D), which entered below the medial epicondyle and perforated the inferior extremity of the humerus until it reached the lateral condyle. Afterward, the olecranon was screwed to its base

FIG. 3-A

FIG. 3-B

Case 3. Anteroposterior and lateral roentgenograms, taken before the operation, showing simple old dislocation of the elbow.

(Fig. 6-C); the forearm had to be nearly straightened because of the shortening of the triceps.

The postoperative course was good. Forty days later, the screws were withdrawn through two small incisions. Flexion-extension movements had increased to about 40 degrees; hot baths and active movement were recommended. When the patient was seen four months after the operation, the range of movement was even greater.

Vachey and Dechaume, using Gigli's saw, cut the olecranon downward, outward, and backward.

FIG. 3-C

FIG. 3-D

Roentgenograms taken a year and a half after the operation, showing elbow in maximum extension and flexion.

According to these authors, the saw is passed from the inside outward to avoid the trochlear border; but this is more difficult.

The transolecranal approach gives ample space, but cuts the articular surface; and, if the replacement of the olecranon is not perfect, an exuberant, osseous callus may limit the movement. As the triceps is usually shortened, it is very hard to replace the olecranon.

FIG. 4-A

FIG. 4-B

Case 5. Anteroposterior and lateral roentgenograms taken before the operation.

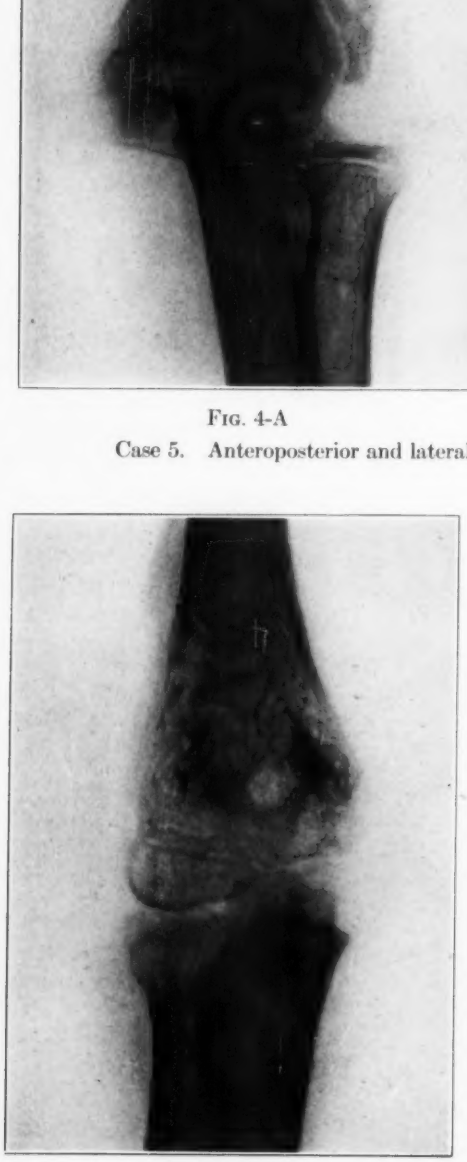

FIG. 4-C

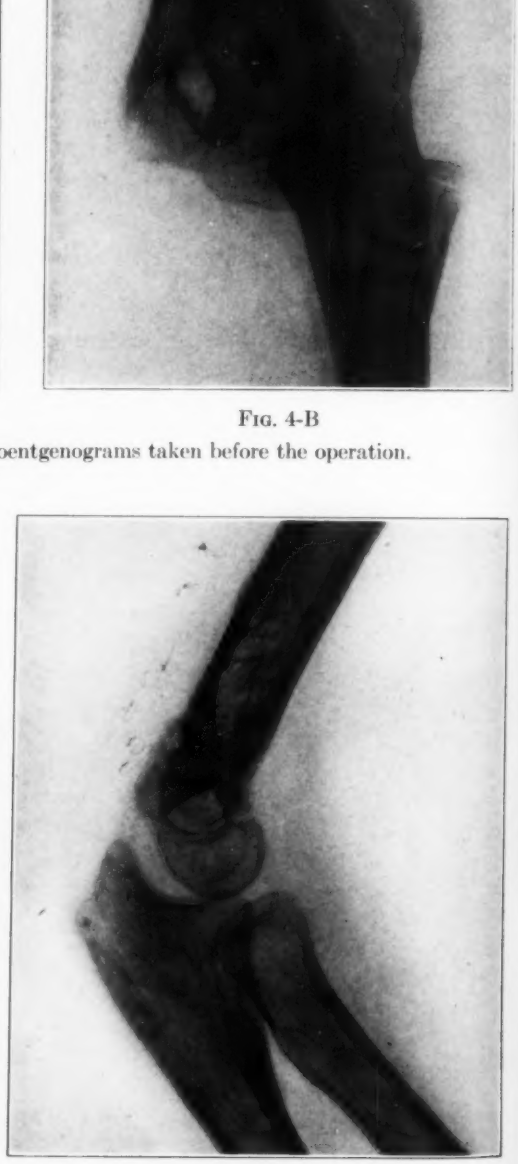

FIG. 4-D

Roentgenograms taken two months after the operation.

unless the forearm is placed in a straight line; and sometimes, even in this position, it does not adapt itself properly. Therefore, it is necessary to lengthen the triceps tendon; but this interferes with the blood supply of the tip of the olecranon. In such a case it is preferable to excise the inferior extremity of the humerus.

Transtendinous Approach

This approach is the best for old dislocations of the elbow. It affords ample view of all the dislocated surfaces. It allows room to excise thoroughly all newly formed tissue. The ulnar nerve can be easily retracted. No important organ is cut. Postoperative accidents are at a minimum. This approach is recommended by Tavernier, Pouzet, Campbell, Van Gorder, Allende, and others.

TECHNIQUE

The surgical technique we now practise is the following:

1. An Esmarch bandage is started at the proximal end of the limb. It is tightened lightly on the first turns, the pressure being increased only after the third or fourth turn. Since this has been done, the temporary paralysis of the ulnar nerve, seen in our first cases, has been absent.

2. The anaesthetic used is ether.

3. The position is important. Sometimes the arm is kept in front of the thorax, but it is preferable to have the patient lying face downward on the operating table, with the elbow on a side table.

4. The incision varies. At first the "inverted goblet" incision was used; but it was noticed that the wounds healed slowly and interfered with the exercises that have to be practised after the operation. So one of the arms of the "goblet" was eliminated, and a "bayonet" incision remained, inverse to that of Ollier. The skin incision is of little importance, the only essential condition being that it be ample, because it has to afford, after the dissection, a clear view of the posterior aspect of the joint. We have never had trophic changes in the wounds of our patients, even though ample dissections have been per-

FIG. 4-E

FIG. 4-F

Roentgenograms taken eight months after the operation, showing the elbow in maximum extension and flexion.

FIG. 5-A

FIG. 5-B

Case 18. Anteroposterior and lateral roentgenograms showing old dislocation of the elbow, with ossification of the radiohumeral "horn" twenty-five days after injury.

formed; and, as Vachey and Dechaume recommend, we do not believe it necessary to limit the dissection to less than two centimeters to ensure adequate blood supply.

5. In liberating the ulnar nerve, the fibrous tissue is carefully cut with a scalpel, and the ulnar-nerve sheath is uncovered. The sheath is incised with Mayo scissors, and the nerve is well exposed in its entire length, until the flexor carpi ulnaris is reached. The muscle fibers are incised up to the base of the olecranon. A loop of gauze tape is placed around the nerve to facilitate its retraction during the operation.

6. Section of the triceps tendon is accomplished by severing it in the manner shown in Figure 1-A. We try to leave the thickest and most solid part of the tendon inserted to the olecranon, because, after reviewing our old cases in which Z sections had been made, we have sometimes seen the function of the triceps diminished or completely lost. Although this complication does not cause much disablement, it has not occurred in cases where we have used our present technique.

7. In opening the joint, it is necessary to reflect the triceps tendon toward the forearm, and retract the lateral head of the triceps. All fibrous tissue that covers the joint is incised with the scalpel. On either side, also with the scalpel, the soft tissues are cut until the head of the radius is exposed laterally, and all of the inferior epiphysis of the humerus, medially (Fig. 1-B).

8. After incising all these tissues, the forearm is flexed. Simultaneously, all adhesions that impede flexion are broken down to avoid harm to the articular surfaces.

9. Once the joint is completely open, and the bony extremities are dislocated outward, the surgeon proceeds to remove all fibrous tissue, and, with a chisel and hammer, eliminates the radiohumeral "horn" and all other ossifications that are around the lower humeral extremity. The fibrous tissue that fills the greater sigmoid cavity and the articular surfaces of the inferior epiphysis of the humerus is excised with the scalpel.

10. The dislocation is reduced, great care being taken that nothing interferes with the normal movement of the elbow; should there be anything in the way, it must be removed.

11. In suturing the triceps tendon, we have usually used silk, boiled in oxycyanide of mercury, following Lange's technique. We have used catgut a few times; but in our last three cases by the use of No. 34 stainless-steel wire, we have obtained a strength of the triceps equal to that of the other arm.

12. The parts on either side are sutured with catgut. Many times the bony parts

FIG. 6-A

FIG. 6-B

Case 31. Old dislocation of the elbow, with fracture of the lateral condyle.

FIG. 6-C

FIG. 6-D

Fixation with screw, forty-five days after trauma.

stay directly in contact with the aponeurosis or the skin through lack of sufficient muscle tissue to cover the wound.

13. The ulnar nerve is replaced in its correct position, or over the anterior aspect of the medial epicondyle, surrounded by the epitrochlear muscles.

14. The skin is sutured.

15. A plaster-of-Paris cast is fitted to the elbow, extending from the shoulder to the metacarpophalangeal joints. The elbow is fixed at an angle of 140 degrees in those cases in which the reduction is very stable; but, when the joint tends to redislocate after suture of the muscles, it should be fixed at an angle of 90 degrees.

Postoperative Treatment. Eight or ten days after the operation, the cast should be opened. Active movement is begun, with but little extension at first. On the fifteenth day, the skin sutures are removed. Exercises are continued; and hot salt baths are used. The cast should be kept on the arm until the end of the first month, except when exercises or baths are being taken.

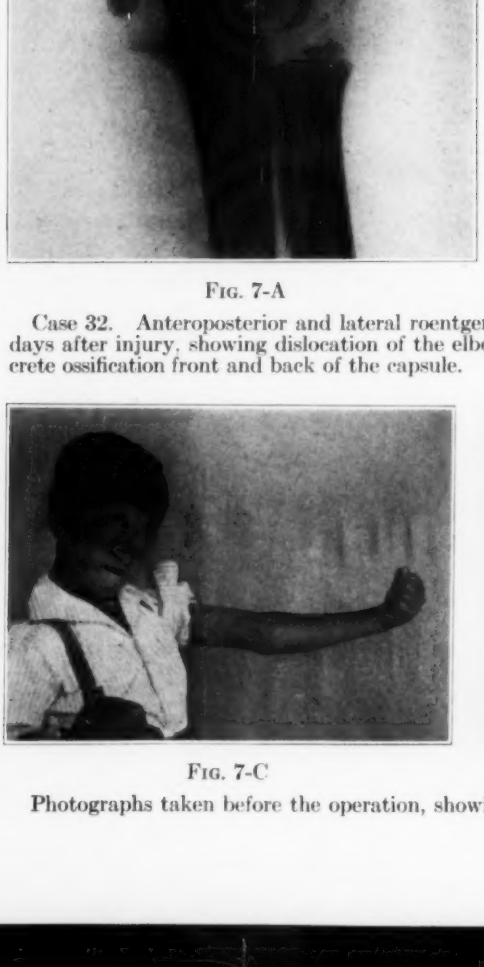

FIG. 7-A

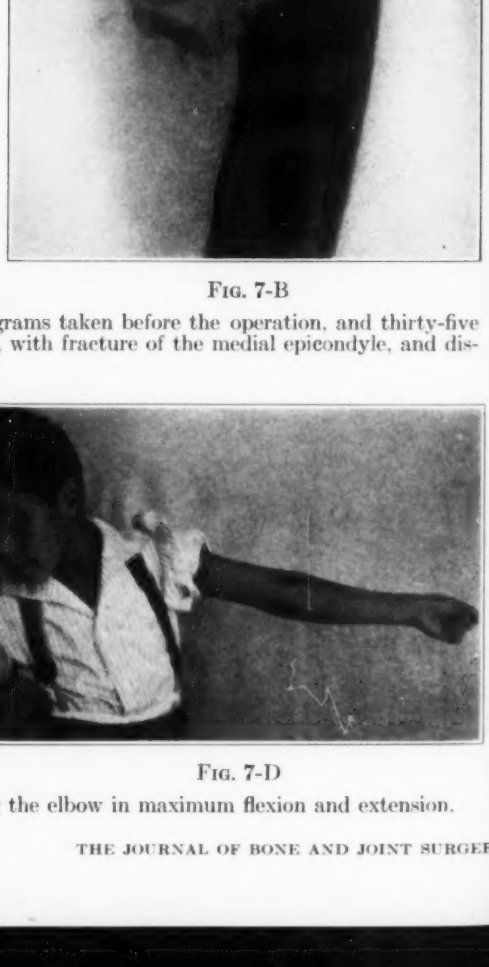

FIG. 7-B

Case 32. Anteroposterior and lateral roentgenograms taken before the operation, and thirty-five days after injury, showing dislocation of the elbow, with fracture of the medial epicondyle, and discrete ossification front and back of the capsule.

FIG. 7-C

FIG. 7-D

Photographs taken before the operation, showing the elbow in maximum flexion and extension.

FIG. 7-E

FIG. 7-F

Photographs taken ten years after the operation, showing the elbow in maximum flexion and extension. The useful range of movement is 70 degrees.

FIG. 7-G

FIG. 7-H

Roentgenograms taken ten years after the operation, showing the elbow in maximum flexion and extension.

CASE REPORTS

CASE 3. G. del V. G., a boy, thirteen years of age, fell and injured his elbow. There were pain and swelling and complete loss of flexion-extension movement. Pronation and supination were very limited, and the elbow was rigid at 170 degrees.

He had been treated first by a bone-setter, who recommended massage and fomentations.

He was brought to us a month and a half afterward. The elbow was in complete extension, and could not be changed by either active or passive movement. The joint was deformed, the crease in the anterior aspect had disappeared, and had been replaced by a bony prominence with all the characteristics of the inferior epiphysis of the humerus. The tip of the olecranon was above the bi-epicondylar line. There was marked muscle atrophy, but no nerve injury.

Roentgenographic examination confirmed the diagnosis of simple old dislocation of the elbow.

Treatment was by operation, under ether anaesthesia. An Esmarch bandage was adjusted at the proximal end of the limb. A "bayonet" incision of the skin was made. The ulnar nerve was dissected and

retracted with a gauze tape. Then the triceps tendon was severed, as shown by the dotted line in Figure 1-A. After the joint had been opened, all fibrous tissue was excised, the humeral "horn" was removed, and the joint was reduced. Reconstruction of the triceps tendon was done with X stitches of chromic catgut. A few stitches were placed in the subcutaneous tissue, and the skin was sutured. A cast was applied, while the elbow was held at a right angle.

Healing of the wound was by first intention. When the patient was examined a year and a half afterward, the elbow was found to be functionally useful. Extension reached 150 degrees, and flexion 20 degrees. The useful range of movement was 130 degrees (that of the normal elbow is 150 degrees). Marked weakness of the triceps tendon was present. (See Figures 3-A, 3-B, 3-C, and 3-D.)

CASE 5. E. T., a boy, nine years of age, fell and injured his elbow, which became very swollen and deformed. No flexion-extension movement was possible. A bone-setter tried to correct the injury, but failed. As every effort to regain movement was unsuccessful, he was brought to us one month after the trauma.

Upon examination, we found extreme displacement of the elbow. The anteroposterior diameter was equal to the transverse. The joint was fixed at an angle of 140 degrees. On the anterior aspect was a bony prominence that had all the characteristics of the inferior extremity of the humerus. On the posterior aspect, the olecranon was found above its normal position in relation to the bi-epicondylar line. Muscle atrophy of the arm was present, as well as sensory changes in the median-nerve area.

Roentgenographic examination confirmed a diagnosis of old dislocation of the elbow, with simple posterolateral displacement.

Treatment was by operation, under ether anaesthesia, following the authors' usual method. An Esmarch bandage was placed around the arm. A posterior "bayonet" incision of the skin was made. The ulnar nerve was dissected free of surrounding tissue and retracted with a loop of gauze. Then the triceps tendon was cut, as is shown by the dotted line in Figure 1-A. The joint was freed from newly formed tissue. On the posterior aspect of the humerus, osseous tissue had formed, enclosing a thick nerve cord, which we assumed to be the median nerve. After excising the osteoma, the nerve cord was placed in front of the joint, the joint was reduced, and the triceps tendon was sutured with steel wire. A few stitches were placed in the subcutaneous tissue, and then the skin was sutured with steel wire. Gauze was placed on the wound, and reduction was maintained by putting on a plaster-of-Paris cast immediately afterward. The joint was fixed at an angle of 90 degrees.

Healing of the wound was by first intention. Postoperative treatment was routine. Eight months afterward, the patient was examined, and the arm was found to be functionally useful. Extension reached

FIG. 8-A

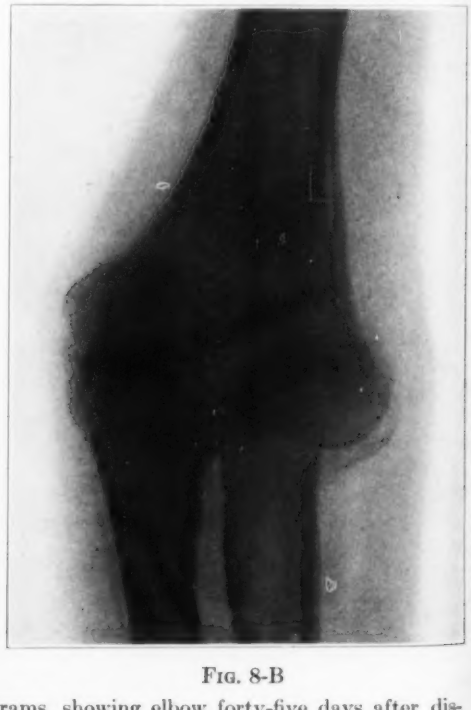

FIG. 8-B

Case 33. Lateral and anteroposterior roentgenograms, showing elbow forty-five days after dislocation, with radiohumeral "horn", and ossification of the anterior surface of the capsule (the osseous "anterior slab" of Delbet).

140 degrees and flexion 80 degrees. The useful range of movement was 60 degrees. The hypaesthesia persisted in the median-nerve area. (See Figures 4-A, 4-B, 4-C, 4-D, 4-E, and 4-F.)

CASE 32. S. H., a boy, eight years of age, fell from a donkey, and injured his elbow. The elbow became deformed and very painful, and could not be moved. He was treated by a bone-setter who tried to correct the deformity by manipulation, but failed.

One month later, he was brought to us. We found the elbow fixed in extension. On the anterior aspect was a bony prominence with all the characteristics of the inferior extremity of the humerus. The tip of the olecranon was high, and was no longer in normal relation to the bi-epicondylar line. Discrete atrophy of the muscles of the arm was observed, but no sensory changes were evident.

A diagnosis of old dislocation of the elbow, with fracture of the medial epicondyle was confirmed by roentgenograms.

Treatment was by operation, done under ether anaesthesia. An inverted "goblet" incision of the skin was made. The ulnar nerve was retracted medially. The triceps tendon was cut with a Z incision. The articular surfaces were cleared of excess tissue, and the joint was reduced. After suture of the triceps tendon, a few stitches were placed in the subcutaneous tissue, and the skin was sutured. Gauze was placed on the wound, and a cast was fitted with the arm at an angle of 90 degrees.

The wound healed by first intention.

Ten years after the operation, the patient visited us again. The elbow was firm and painless, and the arm was useful. Maximum active flexion reached 30 degrees, and maximum extension 100 degrees. The range of useful movement was 70 degrees. (See Figures 7-A, 7-B, 7-C, 7-D, 7-E, 7-F, 7-G, and 7-H.)

BIBLIOGRAPHY

1. ALGLAVE, M. P.: Application de la voie transolécranienne à une fracture transversale située à la limite du tiers moyen et du tiers inférieur de l'humerus. Bull. et Mém. Soc. Nat. de Chir., LV, 1028, 1929.
2. ALLENDE, J. M.: Luxación postérior inveterada de codo. Reducción cruenta. Bol. y Trab. de la Soc. de Cir. de Buenos Aires, XVII, 860, 1933.
3. ALLENDE, J. M.: Vías de penetración a la articulación del codo. Rev. de Cir. de Buenos Aires, XII, 834, 1933.
4. BERTOLA, V. J.: Acceso a la articulación del codo (una nueva incisión para llegar a ella). Prensa Méd. Argentina, XXVIII, 479, 1941.
5. BERTOLA, V. J.: Vías de abordaje al codo; comentarios clínicos y generales; contribución a la restauración articular anatomo-fisiológica. Prensa Méd. Argentina, XXX, 1047, 1943.
6. BOYER: *Quoted by* Rouvillois.
7. BROCA, ANDRÉ: Chirurgie Infantile, p. 22. Paris, G. Steinheil, 1914.
8. CAMPBELL, W. C.: Operative Orthopedics, p. 473. St. Louis, The C. V. Mosby Co., 1939.
9. CATTANEO, F.: Il trattamento cruento delle fratture e lussazione inveterata del gomito col metodo transolecranico. Arch. di Ortop., L, 741, 1934.
10. COOPER, SIR ASTLEY: *Quoted by* Rouvillois.
11. DENUCÉ, PAUL: *Quoted by* Rouvillois.
12. DOLLINGER, JULIUS: Die operative Einrenkung veralteter Ellenbogenverrenkungen. Deutsche Ztschr. f. Chir., C, 38, 1909.
13. FARABEUF, L. H.: *Quoted by* Broca.
14. FREYTES, M. V.: Luxación inveterada de codo. Tratamiento. Tesis de doctorado. Universidad Nacional de Córdoba, 1938.
15. GOÑI MORENO, I.: Vía de acceso posterior a la articulación del codo. El Día Méd., Ed. Especial No. 2, 31, 1940.
16. HENNEQUIN, J.: *Quoted by* Rouvillois.
17. KOCHER, THEODOR: Chirurgische Operationslehre. Jena, Gustav Fischer, 1902.
18. LECÈNE, P., ET HUET, P.: Chirurgie des os et des articulations des membres, p. 256. Paris, Masson et Cie, 1929.
19. LEXER, ERICH: Die Gesamte Wiederherstellungs Chirurgie. Band II, S. 657. Leipzig, Johann Ambrosius Barth, 1931.
20. MACAUSLAND, W. R.: Mobilization of Ankylosed Joints. Surg. Gynec. Obstet., XXXVII, 255, 1923.
21. MALGAIGNE, J. F.: *Quoted by* Rouvillois.
22. NÉLATON, A.: *Quoted by* Rouvillois.
23. NOVÉ-JOSSERAND ET POUZET, F.: Résultats éloignés d'hémi-résection et de résections pour luxations anciennes du coude. Lyon Chir., XXIX, 610, 1932.
24. OLLIER, L.: Traité des résections et des operations conservatrices qu'on peut pratiquer sur le système osseux, p. 968. Paris, G. Masson, 1891.
25. PUTTI, V.: L'interposizione di lembi aponeurotici liberi nella movilizzazione chirurgica delle anchilosi e delle rigidità articolari. Arch. di Ortop., XXX, 129, 1913.

26. Quenu: *Quoted by* Rouvillois.
27. Richard, P. L.: Luxation postéro-externe du coude droit, complète en ce qui concerne le radius, incomplète en ce qui concerne le cubitus.—Reduction le 141e jour.—Amélioration fonctionnelle considérable. Arch. de Méd. et de Pharm. Militaires, XL, 500, 1902.
28. Rouvillois, H., et Maisonnet: Lésions traumatiques des articulations. *In* Nouveau Traité de Chirurgie Clinique et Opératoire, par A. Le Dentu et Pierre Delbet. IX, p. 527. Paris, J. B. Baillière et Fils, 1935.
29. Serra, A.: Il tratamento ortopédico delle rigidità e delle anchilosi. Relazione all' XI Congreso Italiano di Ortopedia. Roma, 1920.
30. Speed, J. S.: An Operation for Unreduced Posterior Dislocation of the Elbow. Southern Med. J., XVIII, 193, 1925.
31. Tavernier, L., et Pouzet, F.: Le traitement des luxations anciennes du coude. Technique de la réduction sanglante. J. de Chir., XLIII, 161, 1934.
32. Vachey, A., et Dechaume, M.: Étude sur la voie transolécranienne dans la reposition sanglante des luxations anciennes du coude. Rev. d'Orthop., XIV, 199, 1927.
33. Van Gorder, G. W.: Surgical Approach in Old Posterior Dislocation of the Elbow. J. Bone and Joint Surg., XIV, 127, Jan. 1932.
34. Watson-Jones, R.: Fractures and Other Bone and Joint Injuries, pp. 369, 370. Baltimore, The Williams and Wilkins Co., 1940.

DISCUSSION ON PAPERS ON AMPUTATIONS

(*Continued from page 671*)

can be obtained. Civilian limb makers, who have had the opportunity of visiting some of the Army Amputation Centers, have told me that on the average, the stumps they have seen there are far better than those that they have to fit in civil life. Also, the Army has gone far ahead in developing the program of temporary prostheses. In the first War, we used plaster pylons. In Canada, pylons with steel reinforced leather buckets are being used today for temporary prostheses. In England, the soldiers with amputations are discharged to the Ministry of Pensions' Hospital at Roehampton, and reconstructive surgery is done there. This is also a limb-fitting center, and veterans are provided with permanent prostheses, generally of the all-metal type. The British surgeons rely almost entirely upon tight bandaging to obtain stump shrinkage. It appears that the average period between surgery and the fitting of this permanent prosthesis is nearly six months. In our Army, the time period between surgery and the application of a temporary prosthesis will average scarcely more than three months; often it is less. Colonel Thompson told us this morning that the limb is ordered when the man is admitted to the Amputation Service, and before reconstructive surgery is done. The limb is waiting for him when he is ready to use it. Although it is the function of the Veterans Administration to supply the permanent limb, the soldier receives his temporary prosthesis before discharge from the Army, and is given instruction in its use. Months of delay are thus avoided, and the soldier is ready to make the best use of his permanent limb, when he finally receives it. His temporary limb will then serve as a spare limb in case of need. Physiotherapy, exercises, occupational therapy, instruction in walking, all are used in the rehabilitation of the amputee at the Amputation Centers. The splendid morale-building film for the education of the man with an amputation of the upper arm, that has been shown us this morning, is only another example of how well this program has been planned.

In spite of the fact that the Army is doing its very best for these cases, it is difficult to satisfy every one. I have heard a number of criticisms of the Army program, and have even seen newspaper articles in which a disgruntled veteran who has had an amputation has expressed his discontent with his treatment. Sometimes a veteran has had difficulty in obtaining service for his limb after discharge from the Army. He may have been sent by the Veterans Administration to a civilian limb maker, who criticizes the temporary leg that the veteran has received from the Army. The limb maker is interested in making a sale of one of his own limbs, and his criticism increases the veteran's discontent. I think that we, as orthopaedic surgeons, can do a great deal to help the Army. We should express our confidence in the rehabilitation program developed by the Army for these amputees. When we hear these stories, we should examine them critically. We should not think so much of the stories of these malcontents, but more of the great host of veterans who have had amputations, and who are satisfied with what has been done for them. They are going ahead and making the best of what they have. I would appeal to you to take home all that has been shown in the program this morning, so that, when you hear complaints, which you eventually will, you will know how to answer them.

INTERNAL FIXATION FOR INTERTROCHANTERIC FRACTURES

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Over five years ago the authors began to use internal fixation for the treatment of intertrochanteric fractures. This is a report of our conclusions after the study of a series of 159 cases treated by open reduction. Our first report was made in 1940, as an exhibit at the meeting of The American Academy of Orthopaedic Surgeons. At that time our observations were based on fifty-seven cases treated by open reduction. A somewhat larger group of cases (108) treated during the same period by closed methods were studied for comparison. It was found that the average age of the patients ran a close parallel to that observed in patients with fractures of the neck of the femur during the same period, and that the number was approximately equal.

FEMORAL NAIL-PLATE

We are not presenting a new method of treatment, but the nail used in the internal fixation of intertrochanteric fractures, designed by one of us (A.J.N.), is novel in construction. As shown in Figure 1, it consists of one piece, pressed into a V shape, with a constant angle of 135 degrees. The material is 18–8, type 302, stainless steel. *B* illustrates the type of handle which is used to insert the nail; this same handle may also be used to remove it. There are two holes near the lower end of the plate through which

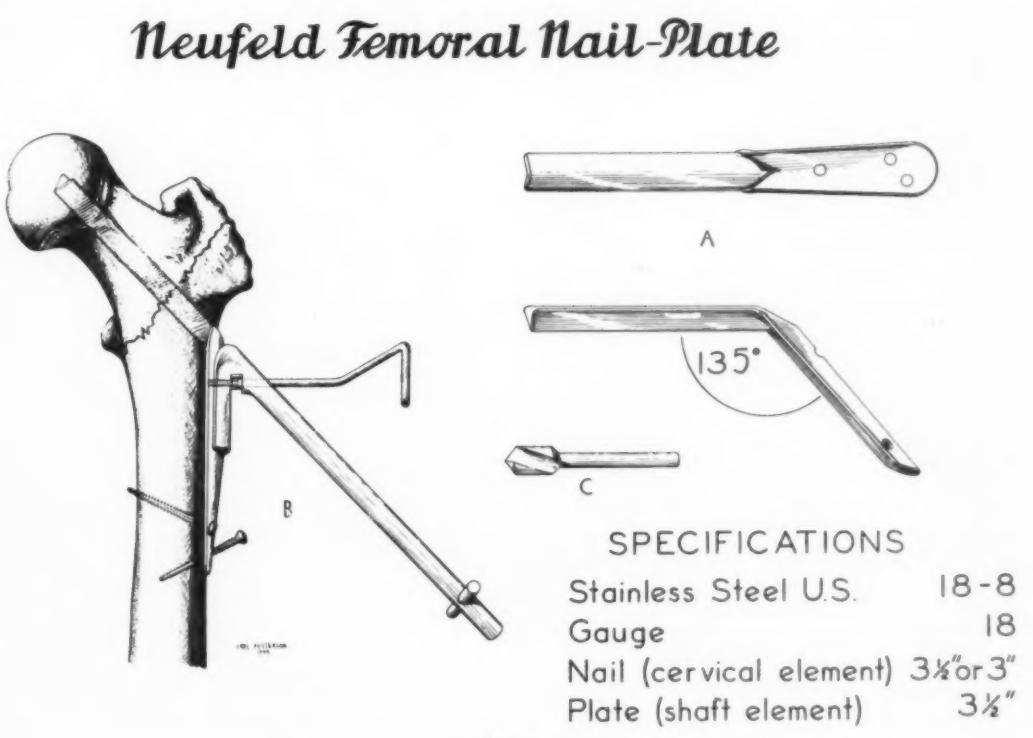

FIG. 1

A femoral nail-plate; *B* handle; and *C* drill point, one-half inch wide.

screws, one and one-half inches long, are driven to secure the plate to the lateral side of the shaft of the femur. This particular type of construction provides sufficient strength to maintain position under a force on the point of the nail of forty or more pounds.

In only two cases in this series were the nail-plates broken, both at the angle, and in patients who were permitted to walk before bony union had taken place.

For subtrochanteric fractures, a femoral nail-plate has been made with the plate considerably longer. The use of this has proved very successful in many cases that have defied closed reduction, especially where the upper fragment was too short for the application of a simple plate.

OPERATIVE TECHNIQUE

The operative technique is important in determining the end results, even for surgeons who have had a great deal of experience in using other types of fixation for fractures of the neck of the femur. The immediate success of the operation depends to a large degree upon the cooperation of the operating team. The following is the operative procedure which has proved most satisfactory in this series of cases.

Anaesthesia

The anaesthetist plays a very important part in the team, since it is his judgment which frequently makes possible surgery which otherwise seems hopeless. In general, the aged will stand only about half the premedication and anaesthetic dosages administered to middle-aged adults. If this is kept in mind, with the usual precaution for certain types of anaesthesia, most of the anaesthetics ordinarily employed can be used. For patients who are poor surgical risks, a local novocain anaesthetic is preferred, coupled with intravenous pentothal sodium in minimal amounts, to prevent excessive movements and to merely obliterate consciousness. Spinal anaesthetics have been used in a large number of these patients in amounts of forty to ninety milligrams of novocain, with an average of sixty to eighty milligrams. Spinal anaesthetics are ordinarily not desirable in hypertensive patients.

Approach

A lateral incision is made, just posterior to the middle of the lateral surface of the femur, beginning at the greater trochanter and extending downward for about six inches. The upper end of this incision, when carried through the iliotibial band, should not invade the tensor fasciae latae. Where more exposure is desired, the incision may be curved forward. As soon as the iliotibial band has been divided longitudinally, the loose areolar tissue which forms the gliding surface over the greater trochanter is exposed. The incision to expose the femur is made by sectioning the origin of the vastus lateralis transversely, close to the inferior border of the greater trochanter, and longitudinally along the shaft of the femur near the linea aspera. Then, by turning the vastus lateralis forward from the shaft as far as necessary, a generous exposure of the femur in this region over the entire lateral surface is obtained, with very little bleeding or muscle damage. A deep retractor pulls the angular muscle flap forward.

At this point, an opening is prepared, in the lateral surface of the femur, through which the nail portion of the nail-plate is to be inserted. This can be done easily by using a drill, one-half inch in diameter, to drill very carefully and gently through the outer cortex only. The placement of this hole is three-fourths to one inch below the inferior border of the greater trochanter, just anterior to the linea aspera. The individual angle of the neck of the femur must be considered. The hole itself may have to be modified with the use of a small chisel to admit the nail easily.

FIG. 2-A

FIG. 2-B

Pertrochanteric fracture. Fractures of the base of the neck must also be stabilized by a method to reinforce the angle.

FIG. 3-A

FIG. 3-B

Typical comminuted intertrochanteric fracture before and after operation.

FIG. 4-A

FIG. 4-B

Comminuted intertrochanteric and subtrochanteric fractures. A separate screw is used for additional support.

Reduction

At this stage, it is desirable to make a test reduction of the fracture. This is done by having the assistant gently exert traction on the leg, with the thigh flexed about 20 degrees, and the knee in a sagittal plane. It is frequently necessary, by manual manipulation, to push the shaft forward on the proximal fragment, or *vice versa*. Once the reduction has been effected, and the fracture lines are smooth, the fragments will stay in position, if the leg is held carefully. Some internal or external rotation is occasionally needed to keep the fracture from opening up, either anteriorly or posteriorly. (In cases where extensive comminution has occurred, it is probably better to use some other type of treatment, even though this method has been and can be used.)

Insertion of Nail-Plate

Once the reduction has been achieved, the nail is inserted in the following manner: The index finger is placed in front of the neck of the femur near the head. This is then used as an aiming point for the handle and nail. The end of the nail is introduced through the drill hole in the lateral cortex of the femur. The entire situation is surveyed carefully in the light of the following questions:

1. Does the line drawn through the handle and nail lead directly to the center of the head of the femur?
2. Does raising or lowering the handle laterally bring the nail more nearly in line with the position of the neck in the coronal plane?
3. With the handle and nail aligned, does the plate lie parallel to the shaft of the femur?

If the hole has been made in the proper position, and if all three of the above criteria have been met, the nail may be gently tapped into position without hesitation and with

reasonable assurance (1) that the position of the fragments will be normal, (2) that the nail will be entirely inside the neck and head, and (3) that the plate will lie along the shaft of the femur smoothly and closely, without further adjusting or bending to assure an adequate fit. The screws are then introduced through the holes in the lower end of the plate and through both cortices of the femoral shaft, the bottom screw directed toward the foot, and the other toward the head. (It is highly important to use the proper drill for the size of the screw in each case. If one is using a 6–32 machine screw, a number 36 drill should be used.) Care must be exercised in drilling through the second cortex so that the drill does not bind, since this is the most frequent cause of breaking of the drill. When the screws have been firmly placed, it should be possible to move the entire extremity just as freely as though there had never been any fracture present. If there is any grating, or if the proximal fragment fails to move normally with the femur, the placement of the pin is defective. It is best to use roentgenographic examination as a guide during the procedure. Closure is done in anatomical layers in the usual manner.

POSTOPERATIVE CARE

The after-care policy is much more liberal than that generally employed in the treatment of patients with fracture of the neck of the femur. The patient is permitted to roll around in bed, to sit up, to move his leg at will, movements being limited only by the amount of pain. This will ordinarily permit patients to be up in a wheel chair within a week or two. Weight-bearing is not permitted until there is roentgenographic evidence of firm bony union, and absence of discomfort at the fracture site when pressure is applied to the bottom of the foot. This period is the usual one of eight to twelve weeks.

END RESULTS

Since the mortality is always of considerable interest, we wish to note that in the first series of 165 cases previously presented, there was an average mortality of 25 per cent. for

FIG. 5-A

FIG. 5-B

A difficult comminuted pertrochanteric and cervical fracture. The small trochanteric fragment is anchored with a loop of stainless-steel wire.

the entire group; in 108 cases treated by external fixation, it was approximately 20 per cent. In the present larger series of 216 cases, in 102 patients operated upon, the mortality was 21.6 per cent.; in 114 patients not operated upon, it was 25.4 per cent. The two series include a total of 381 cases (159 operated upon, and 222 not operated upon). Though the mortality for the two groups of cases was practically equal, the number of those treated by traction who died during the first week was considerably higher than of those operated upon. It is obvious that a number of these died of senility and shock, and should not be included for comparison with the mortality following open reduction. Of those who died, approximately 25 per cent. died in the first week, 50 per cent. during the remainder of the first month, and 25 per cent. two months or so thereafter. This last observation is approximately true of the entire group studied. Postoperative complications are approximately the same as for any other major surgery in this age group. It is surprising how well these older patients do. Infection is seldom seen, and, if present, is usually only superficial in character. Rarely, if ever, does chronic osteomyelitis or persistent drainage result. In this series there was none.

The anatomical results from open reduction have been excellent. It was found that the relative position of the fragments changed but little from that obtained by the surgeon at the time of operation. The restoration of the angle of the neck averaged 3 degrees less than that from closed traction methods, due to the fact that, during the pinning, traction was not efficiently maintained or the angle of insertion was not sufficient for complete correction. Non-union has not been observed except in two cases. In both of these, non-union had resulted from one of the closed methods. Open operation was for the purpose of freshening the fracture surfaces. Immobilization with the femoral nail-plate was used. However, union did not occur, and ultimately a transtrochanteric osteotomy had to be done.

SUMMARY

Internal fixation for intertrochanteric fractures is an effective and efficient method. It also adds greatly to the comfort of the patient, and lessens materially the nursing care.

The femoral nail-plate here presented has had sufficient clinical trial to justify the claim that it will adequately support a fractured intertrochanteric region of the femur without external fixation.

NOTE: Acknowledgment is made to Dr. William A. Clark, Dr. John Dunlop, Dr. Alfred E. Gallant, Dr. Francis McKeever, Dr. Joseph Risser, Dr. Pierre Walker and Dr. John C. Wilson, on whose Services this work was done, for their cooperation and encouragement.

REFERENCES

BARTELS, W. P.: The Treatment of Intertrochanteric Fractures. J. Bone and Joint Surg., XXI, 773, July 1939.

CUBBINS, W. R.; CALLAHAN, J. J.; AND SCUDERI, C. S.: Fractures of the Neck of the Femur. Open Operation and Pathologic Observations. A New Incision and a New Director for the Use of a Simplified Flange. Surg. Gynec. Obstet., LXVIII, 87, 1939.

KEY, J. A.: Internal Fixation of Trochanteric Fractures of the Femur. Surgery, VI, 13, 1939.

NICOLE, R.: Die Indikation bei per- und intertrochanteren Frakturen. Deutsche Ztschr. f. Chir., CCLII, 112, 1939.

PRESTON, M. E.: New Appliance for the Internal Fixation of Fractures of the Femoral Neck. Surg. Gynec. Obstet., XVIII, 260, 1914.

CERVICAL-AXIAL OSTEOTOMY OF THE FEMUR

A Preliminary Report *

BY GUY W. LEADBETTER, M.D., WASHINGTON, D. C.

The problem of non-union in fractures of the femoral neck is fascinating, but baffling. Many are the reconstructive procedures suggested in the literature. Mention should be made of the Whitman type, the Colonna procedure, the Brackett operation, Magnuson's modification, and the McMurray osteotomy. Each of these has added positive knowledge to our theories of the approach to this difficult and distressing condition. Many such operations have been accepted, utilized, and discarded or catalogued for use in a few selected cases. Factors of expediency in elderly patients are important. The operative time, facility of procedure, duration of inactivity and recovery of muscle power, stability, and pain are some of the factors to be considered. With these elements to the fore, there has been a decided swing of opinion toward osteotomy, of which the best example thus far is the McMurray type.

Consideration of the ideal osteotomy for repair of non-union must envisage:

1. Preservation of the articulation of the head and the acetabulum;
2. Establishment of a normal acetabular thrust;
3. Creation of positive pressure by a true valgus;
4. Allowance for contact of cancellous bone surfaces;
5. Preservation of adequate circulation;
6. Production of minimal shortening.

The author wishes to submit the proposition that an osteotomy high in the cervical axis fulfills these requirements. The procedure is expedient, is accomplished under full vision, avoids the ascending ramus of the femoral nutrient artery, as well as the cervical branches of the circumflex femoral artery, and opens the considerable reservoir of blood supply about the greater trochanter. When the osteotomized neck is displaced medially, apposition of abundant cancellous bone is established, with positive pressure beneath the capital portion of the bone in a true valgus position, and the head-to-acetabulum relationship is undisturbed; the acetabular thrust approaches normal; and shortening is minimal.

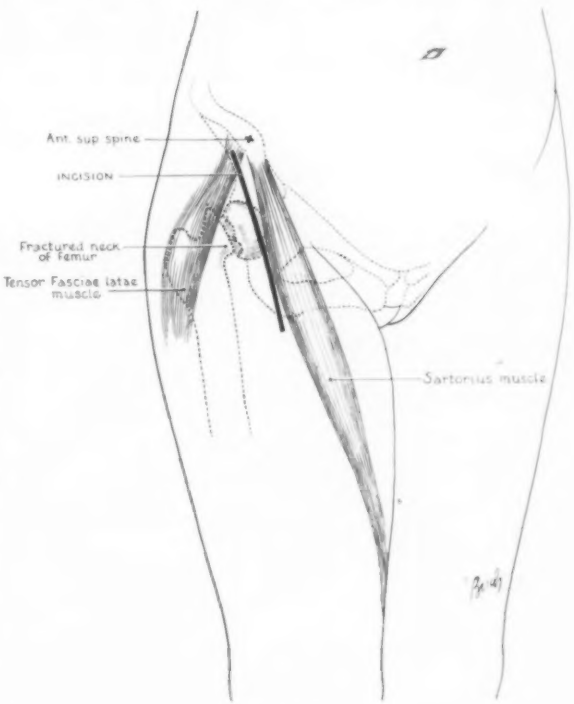

FIG. 1-A

Showing incision with underlying anatomy. Adequate exposure may be obtained by this simple approach.

The osteotomy is accomplished through an anterior approach (subperiosteal dissection of gluteus medius and gluteus minimus is unnecessary). The capsule is opened with a

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 1, 1944.

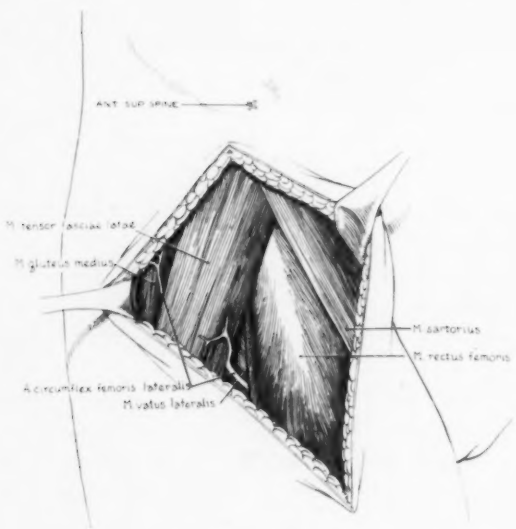

FIG. 1-B

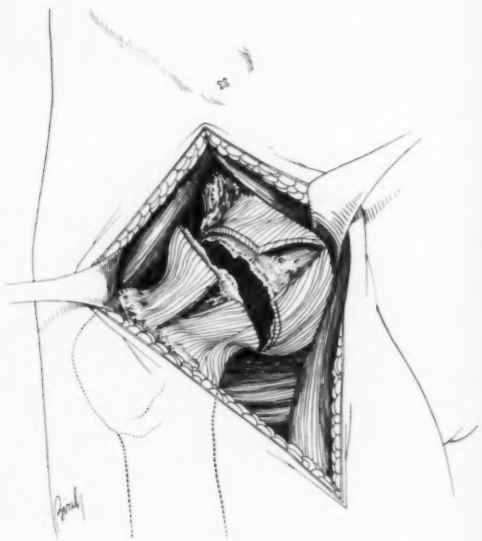

FIG. 1-C

Fig. 1-B: Showing muscles and vessel which should be avoided. Subperiosteal dissection of tensor fasciae latae and gluteus medius is unnecessary.

Fig. 1-C: The sartorius and rectus femoris, with psoas fibers, are retracted medially, and the tensor fasciae latae laterally. An incision is made in the iliofemoral ligament at the fracture line. Stripping of the distal portion of the ligament should be avoided; and all cervical circulation should be carefully preserved.

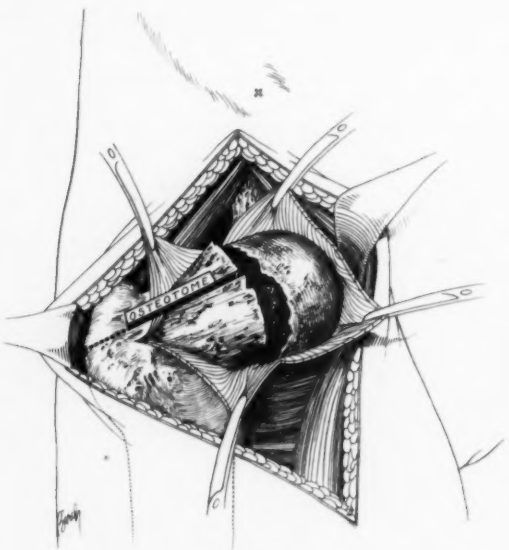

FIG. 1-D

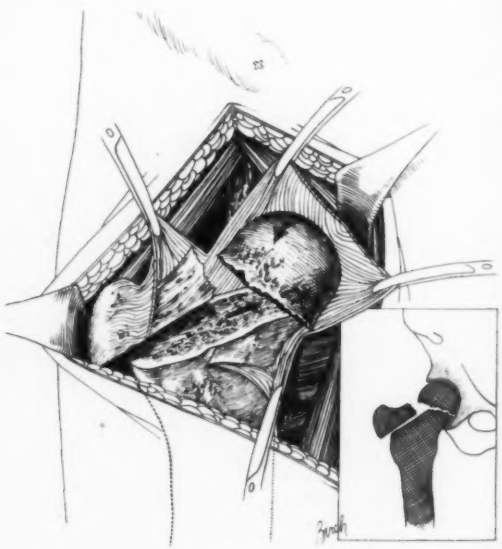

FIG. 1-E

Fig. 1-D: The total fracture is exposed; the osteotomy is performed in the line indicated, and is completed through the base of the greater trochanter.

Fig. 1-E: Showing displacement of the neck beneath the head within the inferior acetabular rim. This displacement assures a valgus thrust and positive pressure of cancellous bone.
The insert shows the position of the fragments following the osteotomy. No fixation of the trochanteric portion is necessary.

cruciate or semilunar incision. The inverted leg presents the neck clearly. If there are comminuted or projecting fragments at the lower portion of the head, they are removed. An osteotomy in the long axis of the neck of the femur, at the junction of its middle and upper thirds, is completed through the neck of the femur and the base of the greater trochanter, in the same axial line. The upper fragment is allowed to remain free and the

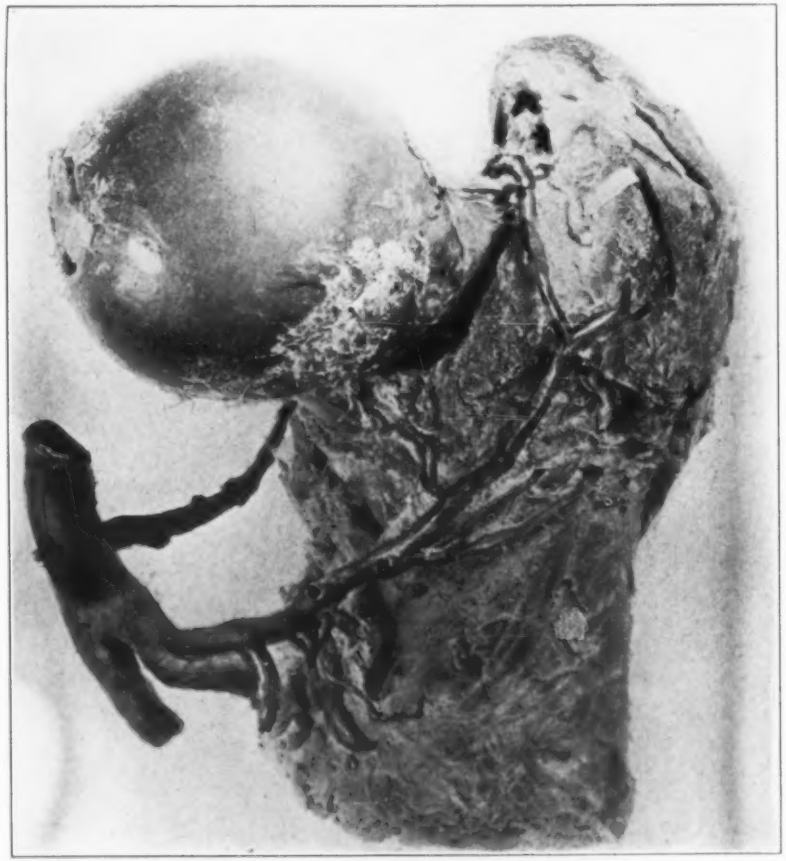

FIG. 2-A

Anterior aspect of the femoral neck, showing the low position of the anterior portion of the circumflex artery. Note the large branch at the inferior portion of the neck and the large branches entering the bone below the base of the greater trochanter. The osteotomy is done above these levels. *(Illustration is reproduced by courtesy of Dr. John Fahey.)*

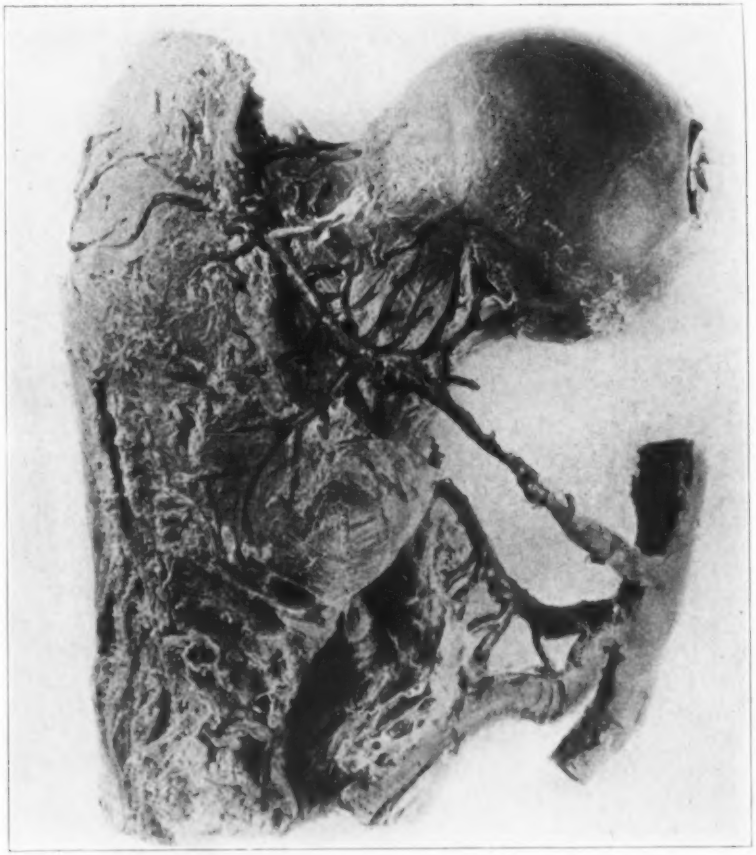

FIG. 2-B

Posterior aspect of the femoral neck showing the cervical branches of the posterior portion of the circumflex artery. Note the liberal blood supply in the lower half of the neck. The osteotomy is done at the junction of the upper and middle thirds, thus avoiding damage to these vessels. *(Illustration is reproduced by courtesy of Dr. John Fahey.)*

FIG. 3-A

McG., sixty-five years of age, had an ununited fracture of the femoral neck of fourteen months' duration.

FIG. 3-B

Four weeks after operation. Note the high level of the osteotomy, the valgus position with positive thrust, and the moderate degree of abduction.

FIG. 3-C

Ten weeks after osteotomy the firm and stable position is noteworthy. The patient is bearing weight at this time.

FIG. 4-A

H. L., aged sixty-six years, had a non-union of two years' duration. One renailing had been done seven months following the primary operation. The nail exhibited here was removed in July 1943, and bone regeneration was allowed to take place.

FIG. 4-B

Four weeks after high cervical osteotomy. Note, in addition to the valgus position, the extreme medial displacement of the shaft and neck.

FIG. 4-C

Twelve weeks after osteotomy, union has occurred in excellent weight-bearing position.

osteotomized neck and femoral shaft are then displaced medially beneath the head, with the help of a small bone hook, to a point within the lower acetabular rim. The head usually rotates to the platform of the neck beneath it. A little abduction ensures this position. The greater trochanter is not fastened to the shaft and the neck, but assumes its own position, and, in the author's experience, has not failed to unite. The closure is routine, and a plaster spica is applied.

Up to the present time eight patients have been operated upon, and the results in them are known. Observation has extended over a period of at least one year, without exception. Every patient has a functioning and weight-bearing hip. Solid union, as evidenced by roentgenographic studies, is present in six.* In two cases, there is considerable limitation in hip motion due to degenerative changes in the joint cartilage, which were present at the time of operation. The remainder have an excellent and comfortable range of hip motion. One knee joint is much limited; this, however, had been restricted by a prolonged prior treatment. The other patients show satisfactory knee function.

The use of plaster for postoperative fixation has in no instance produced any deleterious effect. The plaster is bivalved at the fourth week, and massage and quadriceps-setting exercises are begun. All plaster is removed at eight weeks.

This approach to non-union is suggested, because it has fulfilled certain necessary requirements in the very few patients operated upon, and recovery has been rapid with satisfactory function. The simplicity is equal to that of the McMurray osteotomy; it has the added advantage of being accomplished under full vision. It is realized that the time element for end results is far too short, but the logic of the approach to the problem and the results thus far obtained would seem to justify trial by others in selected cases.

DISCUSSION

DR. J. ALBERT KEY, ST. LOUIS, MISSOURI: Several months ago Dr. Leadbetter showed me this procedure; and, as it seemed good, I have used it in five cases. I liked the method. In my hands there was considerable difficulty in getting the distal fragment down to the lower border of the head and holding it there. I did not put on a large spica, but used a large screw down through the trochanter to the distal fragment. In one of my cases the fragment slipped, and I do not know what to do about it. There is a bare possibility that the patient may get a union like the first case which Dr. Leadbetter showed. I think the operation is very logical.

I had had two non-unions following the ordinary osteotomy done just a little lower, and, consequently, I was anxious to try this. I have always objected to the McMurray osteotomy from the side.

This can be done with a small thin osteotome, and in a rather gentle manner. I have done it on two patients with dead or partly dead femoral heads, and I hope those heads are going to be revivified, but it is too early to say. At this time, it is a toss-up between this osteotomy and the Brackett procedure.

DR. W. P. BLOUNT, MILWAUKEE, WISCONSIN: I should like to congratulate Dr. Leadbetter on his very definite improvement of the McMurray operation. However, I do not believe that McMurray's operation or Dr. Leadbetter's modification is the best procedure to use in the majority of cases of ununited fracture of the neck of the femur. I do not agree that it is desirable to encase a patient in the age group under discussion in plaster-of-Paris, if one can avoid it. Frequently the affected knee is already stiff, as a result of previous treatment. Further fixation is to be employed only if unavoidable.

My chief objection to McMurray's operation is that it does not re-establish function of the hip abductors. Recently I had occasion to examine three patients on whom a McMurray operation had been performed, with what were considered excellent results. In all three, the Trendelenburg sign was positive. All three had rather bad limps. This means fatigue and increasing limitation of function. A good result following osteotomy should presuppose a negative or a weak positive Trendelenburg sign. I believe that the best place for the osteotomy is at the level of the lesser trochanter. The fragments should be angulated, so as to re-establish function of the abductors by forcing the greater trochanter away from the pelvis. Marked medial displacement of the distal fragment is unnecessary. An operation which merely underpins the head and leaves the lesser trochanter high furnishes a bony prop, but inadequate stability. The only way to test the true value of the two operations—the McMurray type and the Schanz type—is to review a comparable

* In the remaining two cases there is still some rarefaction evident in the line of the osteotomy, but functional tests, including active daily routine, indicate bony union.

series of cases, and see which results are the best. I should say that the six criteria proposed by the essayist should be expanded to seven, to include the re-establishment of function of the abductor muscle.

I cannot understand the sudden interest in the psoas. I have never seen any difficulty arise from interference with its function in fractures or osteotomies. It is well known that in trochanteric fractures, the lesser trochanter with its attached psoas is often avulsed, with upward riding. Function is always re-established. The operation described achieves its purpose well, and is ingenious in execution, but it should not include the preservation of the psoas attachment as a talking point.

I shall be interested in hearing the end results in Dr. Leadbetter's cases at a later date. I am sure that the patients will be very much improved by the operation.

DR. RUDOLPH S. REICH, CLEVELAND, OHIO: Being a staunch advocate of the high oblique osteotomy of the McMurray type for ununited fracture of the neck of the femur, I want to congratulate Dr. Leadbetter on his excellent paper, and to emphasize the six points he has brought out, as they sum up the problems involved in this condition. I also wish to congratulate him on the definite contribution to the technique of the McMurray osteotomy, in that he has eliminated the so-called blind phase of the osteotomy by accomplishing a more accurate visualization, and by actually guiding the distal fragment of the osteotomy to its proper objective. Those cases that have been failures—and there have been failures with the high oblique osteotomy—are those in which the osteotomy fragments do not reach the objectives to which they had been directed, or the osteotomy has not been performed at the proper level in spite of the guide pins that have been advocated.

I would like to say one more word about this bugbear of the hip spica. It is my opinion that the objections to the hip spica are more fictional than real. In my personal experience, I have never seen any bad effects from a hip spica in any patient upon whom the high oblique osteotomy has been performed. Many of these patients have had the cast removed in four weeks, as they demonstrated early callus formation through the osteotomy. In my opinion, a short, simple, operative procedure with a hip spica is less hazardous to an old, debilitated patient, than a long complicated one without a hip spica.

I think this paper of Dr. Leadbetter's is a distinct contribution.

DR. RALPH K. GHORMLEY, ROCHESTER, MINNESOTA: Dr. Leadbetter's results look splendid. If he has an osteotomy that really will work, I am willing to change. The reason I have preferred the Brackett type of reconstruction operation is that, as we now do it in Rochester, the procedure gives good fixation of the fragments and allows early movement. We have commenced passive movement of the hip five weeks after this operation. Failure of the Brackett operation usually is attributable to slipping of the fragments but, with transfixion, this is not likely to occur. Transfixion must be done with the fragments held firmly together. If the operation is not carefully done, the fragments may be held apart, which is undesirable. The simplicity of Dr. Leadbetter's procedure appeals to me, and, if it will produce a high percentage of bony union, I shall be glad to accept it.

DR. PAUL B. MAGNUSON, CHICAGO, ILLINOIS: When Dr. Leadbetter was in Chicago a few weeks ago, he told me about this procedure, and a day or two later I had occasion to try it. Of course, I would have the luck to run into difficulty the first time—that is, the tremendous adhesion of the head, with the impossibility of rotation of the head that is met with in some of these old ununited fractures. There is this great advantage in Dr. Leadbetter's procedure, that one can see the amount of fibrous tissue and the adhesion of the head. If the head cannot be rotated, I do not think there is any osteotomy that will meet the requirement of bringing the head and neck into greater alignment with the shaft. If the head is firmly adherent in the acetabulum, the shaft is brought into abduction. We are attempting to throw the head and neck into valgus position, which is good. Granting that the shaft heals to the head and neck in this position, then it is impossible to bring the leg down into normal weight-bearing line with the body, because of strong adhesions around the head and the acetabulum.

It is my opinion, therefore, not based on having done many of these operations, but on general principles, that, if the head moves freely in the acetabulum, this is a good operation. If the head is adherent to the acetabulum, it is not a good operation, because what we are attempting to do is to put the head and neck on top of the shaft, as nearly as possible, and to allow the patient to bear weight directly up through the shaft, the neck, and the head into the acetabulum. After the repair is made, and union occurs, if the leg cannot be brought into a straight line with the body, the operation will not be successful; and the leg will not be brought into line with the body, if the head is adherent. In the appropriate case, I think this procedure of Dr. Leadbetter's will hold more satisfactorily than anything I know of. It is a real contribution, because one can see what he has to deal with.

DR. GUY W. LEADBETTER, WASHINGTON, D. C. (closing): This discussion has been most helpful and encouraging. I think perhaps some of the men were a bit confused as to my original premise. However, this will be clarified as the discussion proceeds.

It should be said that Dr. Albert Key studied two or three roentgenograms briefly, and attempted the operation on his return home. He promised to send me some roentgenograms of these cases, but they arrived only this morning at the hotel. I have examined his two cases, and it is very apparent that the osteotomized surface is not sufficiently displaced beneath the femoral head.

I have no argument with Dr. Blount, except that my statement was that the McMurray osteotomy was considered to be the best type of osteotomy at present, and I still believe this to be true. This is the consensus of opinion; a few of us cannot rule for all. More men, as far as I can determine, are doing the McMurray osteotomy than any other type.

In consideration of the function of the psoas, I believe that the psoas, by its intact insertion on the lower fragment after osteotomy, is extremely helpful in maintaining positive pressure. If the psoas is intact, it tends to place this cancellous structure against corresponding structures of the head. We all know that positive pressure, as brought out years ago by Dr. LeRoy Abbott and Dr. Key, is a factor in consolidation.

With reference to abduction power, it is good in all cases. The Trendelenburg signs were certainly minimal; I do not know whether they were true Trendelenburg signs or not. These individuals had stable hips.

With Dr. Reich I agree completely, that a properly applied hip spica, followed by proper nursing care, should hold no terrors for the intelligent orthopaedic surgeon.

In response to Dr. Ghormley and Dr. Magnuson, it is agreed that the Brackett type of operation is a splendid procedure, but I should like to point out that this osteotomy is much more expeditious and will yield as good a functional result. I think the simplicity is part of the beauty of it. We must wait a year or so to accumulate more cases, before we can determine the end results and the application of this procedure to the problem of fracture of the femoral neck.

Concerning fixation of the head in the acetabulum prior to operation, it may be said that this was not the reason for lost position in the particular case indicated, but the partial displacement hinged on the fact that the neck was not displaced sufficiently medially. There have been one or two cases, where the head was fixed in the acetabulum. I have had no hesitation in removing a sufficient amount of the head to allow displacement beneath it. There is very little motion. However, if a positive thrust with good contact is preserved and circulation is maintained, union usually ensues. I should be delighted to hear of the results of other men.

FRACTURES OF THE ANKLE

BY ERNEST BURGESS, M.D., SEATTLE, WASHINGTON

During the past few years there has been a definite trend toward more frequent primary operative reduction of ankle fractures. Bimalleolar fracture in combination with fracture of a major portion of the posterior tibial articular surface and also injuries with diastasis of the inferior tibiofibular joint are considered often to require open treatment. An occasional reference is made to the desirability of immediate open reduction in certain other ankle injuries.

Open operation in competent hands is surgically justifiable, because fractures of the tibia and fibula, with displacement, and involving the ankle joint, must be accurately reduced and maintained, if one is to expect a maximum or even a tolerable functional recovery. Complete reduction of such fractures by closed methods is often impossible, and fixation by plaster alone is often inadequate. Studies of joint-fusion operations for malunion and post-traumatic arthritis show that the ankle leads the list of major joints requiring arthrodesis. It is an orthopaedic axiom that an ankle with a poorly reduced fracture is unstable and does not long remain symptom-free.

Three years ago, in order to study this group of fractures, the author undertook routine open reduction of all fractures of the ankle with displacement, which came under his care. A number of fundamental principles delineated the technical aspects of this investigation:

1. The tibial and fibular articular surfaces must be accurately restored to their normal anatomical relationship.
2. Stability, both of the fracture fragments and of the joint mortise, must be secured.
3. Open reduction and internal fixation must be adequate to permit immobilization of the ankle and foot in a neutral position in plaster.
4. Weight-bearing in plaster must be made possible much earlier than it can ordinarily be employed, following routine closed methods.
5. Surgical techniques must be of the maximum simplicity consistent with effectiveness.

A careful follow-up of each patient was carried out, the progress of the patient being observed in most instances by both the author and a number of his colleagues. Functional end results were so encouraging and the duration of disability so sharply reduced that it is deemed worth while to review the techniques used and the experience obtained.

FRACTURES OF THE MEDIAL MALLEOLUS

Non-union is one of the common causes of instability in medial malleolar fractures. Non-union and, occasionally, malunion result from soft tissue (periosteum) interposed between the fragments, this condition existing in well over one-half of all cases. Instability results from failure to replace the malleolus accurately by closed manipulation, or to maintain it in position by a plaster splint alone. The resulting offset in the tibial articular surface increases the width of the mortise (accentuated by early weight-bearing), and thereby predisposes to swelling, pain, and weakness.

In performing the primary open operation, a curved incision, four inches in length, paralleling and just posterior to the usual position of the saphenous vein, offers complete exposure. After the fracture has been identified, the malleolar fragment is retracted downward and outward, exposing the ankle joint. Interposed soft tissue is removed. Movement of the ankle with concurrent pressure irrigation with saline solution mechanically cleanses the exposed portion of the joint of blood clot, free bits of bone, and cartilage. The

fragment is then drawn up into anatomical position and held firmly with a uterine forceps or large towel clip. A single Sherman-type vitallium screw is placed obliquely through the malleolus, across the fracture site, and into the diaphysis of the tibia. The talus can then be moved through a full range of motion and rocked laterally without any movement

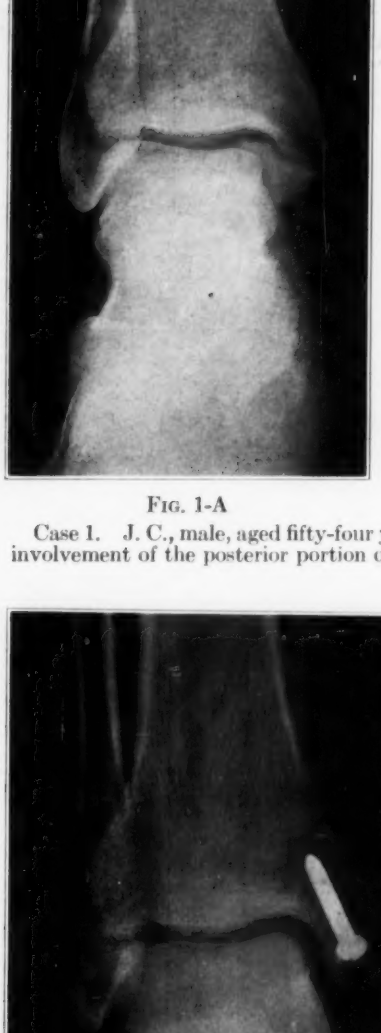

FIG. 1-A

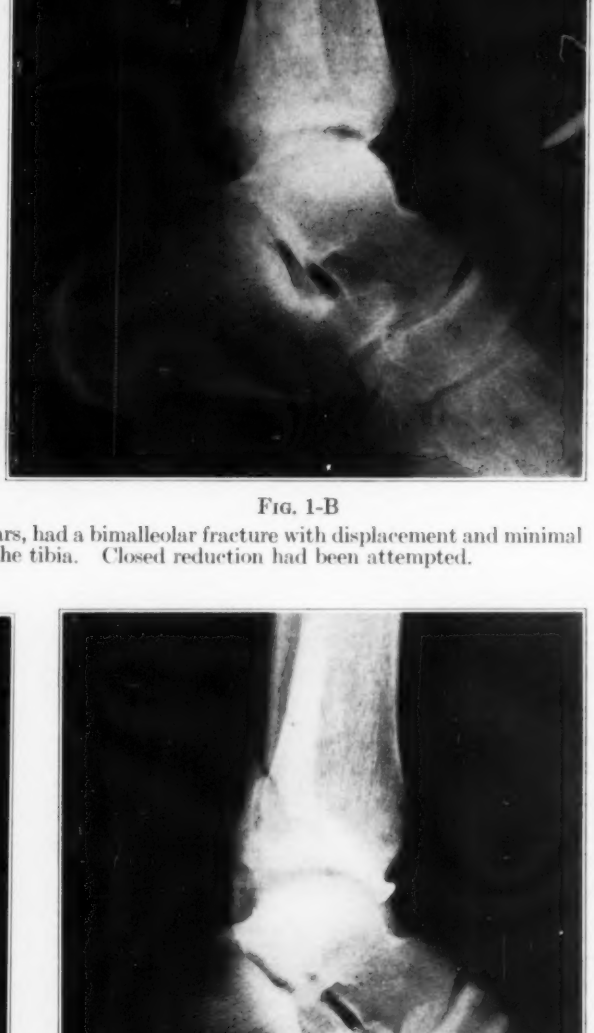

FIG. 1-B

Case 1. J. C., male, aged fifty-four years, had a bimalleolar fracture with displacement and minimal involvement of the posterior portion of the tibia. Closed reduction had been attempted.

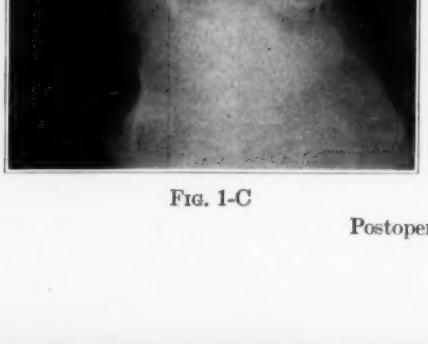

FIG. 1-C

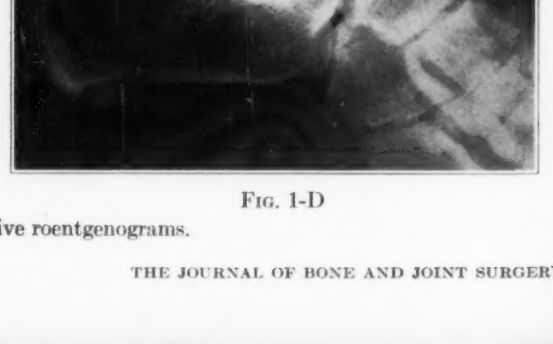

FIG. 1-D

Postoperative roentgenograms.

FIG. 1-E

FIG. 1-F

One year following injury, the ankle was symptom-free and function was normal. Recovery was complete nine weeks following injury.

of the malleolar fragment. Following routine closure, the leg is placed in plaster with the foot and ankle in neutral position. The cast extends to the tibial tubercle only.

Full weight-bearing through a metal stirrup is allowed after the third week. The cast is removed at the end of the fifth week. A normal symptom-free ankle may be expected eight to nine weeks following the date of injury (Case 1).

BIMALLEOLAR FRACTURES

When the distal fibula is also fractured and the talus is displaced medially or laterally, the medial malleolus again offers the key to reduction and stability. The foot is manipulated into normal alignment. A surgical procedure identical to that outlined for the treatment of medial malleolar fractures is then carried out. As the medial malleolar fragment is forced over into position, the deltoid ligament assists in drawing the foot and talus into accurate alignment. Manual pressure against the distal fibula to restore its correct position is seldom necessary. The transfixing screw through the medial malleolus firmly maintains reduction.

The after-care consists of a short leg cast applied with the foot in neutral position. Weight-bearing with stirrup is allowed at the end of three weeks. The cast is removed after six weeks. A normal ankle may be expected in ten to twelve weeks (Case 2).

One is impressed in these cases with the lack of discomfort and the early restoration of function following the removal of the cast. Since it is not necessary to attempt to mold or maintain position by pressure of the cast or by forced inversion of the foot in plaster, soft-tissue changes about the ankle are minimized. Ankle and tarsal stiffness, peroneal spasm, oedema, and other common convalescent difficulties are far less in evidence following open treatment. Early weight-bearing in plaster, which is possible with safety after open reduction, cannot be overemphasized. It is an important factor in the rapid restoration of normal function.

FRACTURES OF THE LATERAL MALLEOLUS

Lateral malleolar fractures with displacement are commonly accompanied by posterior and lateral displacement of the talus and foot. When closed methods alone are used in these cases, complete restoration of the ankle joint mortise is difficult.

Open reduction is accomplished by a lateral, linear incision, directly along the lower three inches of the fibula and across the tip of the malleolus. The periosteum is divided, exposing the fracture site. The distal fragment or fragments are levered outward, so that

the lateral articular surface of the talus and the ankle joint can be visualized. The talus is moved, and pressure saline irrigation cleanses the area of tissue debris and blood clot. With the malleolus then replaced and held firmly in accurate alignment, a screw is placed through it, upward and forward across the inferior tibiofibular joint into the diaphysis of the tibia. A second screw may be used, if further fixation is needed. The extremity is

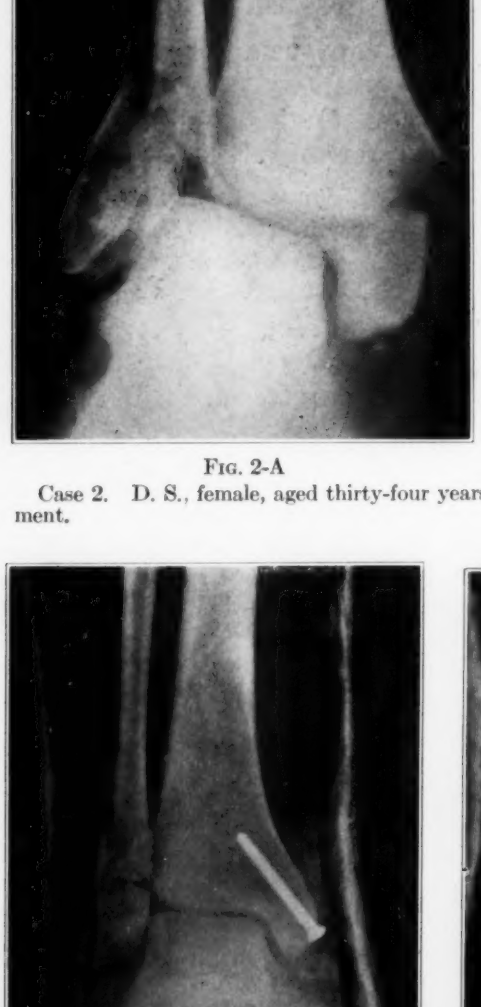

FIG. 2-A

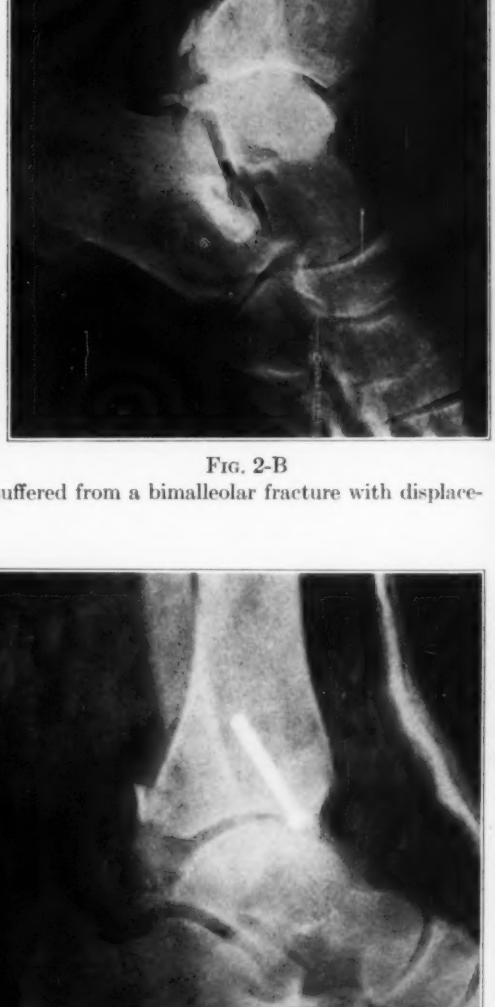

FIG. 2-B

Case 2. D. S., female, aged thirty-four years, suffered from a bimalleolar fracture with displacement.

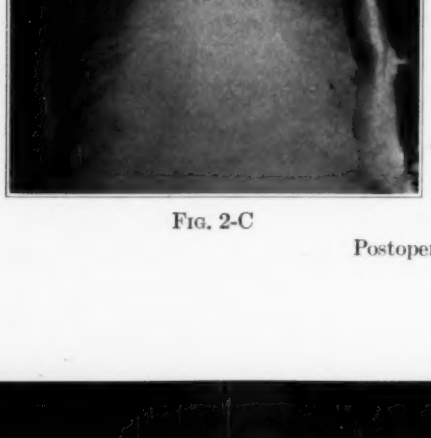

FIG. 2-C

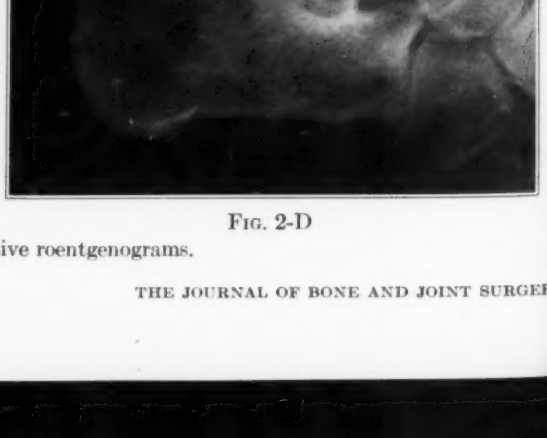

FIG. 2-D

Postoperative roentgenograms.

FIG. 2-E

FIG. 2-G

FIG. 2-F

FIG. 2-H

Ten weeks following injury, slight oedema in the evening and discomfort on continued walking were the only residual symptoms. The patient was otherwise able to carry out her normal activities, and wore no support. She lived in a neighboring community and had been receiving her postoperative care from the referring physician. When asked to come in for photographs ten weeks following injury, she appeared in the footwear illustrated above. She had just returned from an afternoon of shopping, without significant discomfort in her ankle.

then immobilized in a short leg cast of the type described. Weight-bearing is begun at the end of the third week, and the cast is removed at the end of the fifth week. A normal ankle may be expected nine to ten weeks after the date of injury (Case 3).

Meekison plates the fibula in such a case, carrying one or more of the screws completely across the inferior tibiofibular joint into the tibia. The author has not found so extensive an operative procedure necessary, although it might well be indicated when the distal fibular fragment is small.

MALLEOLAR FRACTURES WITH FRACTURE OF THE ANTERIOR OR POSTERIOR PORTION OF THE TIBIAL ARTICULAR SURFACE

Fractures with displacement, which involve the lateral and medial malleoli and a portion of either the anterior or the posterior tibial articular surface are included in this group. The surgical problem depends upon the size and degree of displacement of the third fragment or fragments.

Where the posterior portion is involved to an extent of less than one-fourth of the articular surface, and where the minor fragment is displaced only slightly upward, or, if further displaced, can be reduced manually to near its normal position, it need not be replaced surgically. In that event, after grossly aligning the ankle by closed manipulation, the usual operative procedure and after-care outlined for bimalleolar fractures are carried out. If more than one-fourth of the posterior articular surface of the tibia is involved, and if *any* appreciable displacement is evident by roentgenogram, that articular offset must be accu-

FIG. 3-A

FIG. 3-B

Fig. 3-A: Case 3. J. B., male, aged forty years, had a fracture of the lateral malleolus with minimal lateral displacement of the talus. It is important to correct even this mild increase in mortise width.

Fig. 3-B: Postoperative roentgenogram. Complete functional recovery was obtained ten weeks following injury.

rately reduced and maintained as an integral part of the open surgical procedure. In addition to securing the medial malleolus in place with a metal screw, the posterior portion of the tibia, including the ankle joint, is exposed through a four-inch incision, paralleling and just lateral to the Achilles tendon. The flexor hallucis longus tendon and associated structures are retracted medially. It is not necessary to divide the Achilles tendon. The fracture lines are identified. After the fragments have been accurately reduced and maintained by pressure, one or two vitallium screws are placed obliquely through the posterior fragment, across the fracture line, and into the intact body of the tibia. A circular plaster cast, extending from just below the groin to the toes, is applied. The knee is immobilized in 20 degrees of flexion, with the ankle at a right angle and in a neutral plane.

After three weeks, the long plaster is removed, and a short walking cast is applied. Weight-bearing is then gradually begun. The cast is removed at the end of the sixth week, at which time the patient is bearing full weight. A normal ankle may be expected at the end of ten to twelve weeks (Case 4).

When the anterior articular surface of the tibia, rather than the posterior, is the site of the fracture, and when displacement is present, it is necessary to restore this surface perfectly, even though the fragments may be small. Occasionally this can be done by closed manipulation. It is most effectively handled, however, by open reduction. A three-inch incision is made longitudinally between the tendons of the tibialis anterior and the extensor hallucis longus. The lower, anterior aspect of the tibia, and the front of the ankle joint are exposed, care being taken to carefully retract lateralward the anterior tibial artery and deep peroneal nerve. With the fracture identified, complete reduction under direct vision can be secured. Fixation is accomplished by one or two vitallium screws placed through the anterior fragment and across the fracture lines into the body of the

FIG. 4-A

FIG. 4-B

Case 4. H. M., male, aged forty-seven years, had fracture, with displacement, of the medial and posterior tibial articular surfaces and an associated fracture of the lower shaft of the fibula.

FIG. 4-C

FIG. 4-D

Postoperative roentgenograms. Reduction of the medial malleolar fracture was not quite complete. Complete reduction could be accomplished in this case by an additional operative incision and screw fixation through the medial malleolus. A satisfactory functional result was obtained.

tibia. Excellent stability is thus provided. Reduction and maintenance of internal and external fractures are accomplished, when necessary, by medial-malleolar screw fixation, as previously described. Wound closure, application of plaster, and after-care have been outlined in the preceding paragraphs.

By this utilization of open methods, these complicated ankle fractures lend themselves to accurate and positive control. Faulty reduction, displacement of fragments in plaster, delayed union, and other pitfalls productive of poor functional results can be largely avoided. As with the less severe ankle injuries, we have been impressed by the rapid recovery and disappearance of convalescent symptoms, where open reduction has been properly executed.

DIASTASIS OF THE INFERIOR TIBIOFIBULAR JOINT

This lesion may occur either as an isolated injury or associated with one or more fractures. Not uncommonly the joint is disrupted, as the talus is forcibly carried backward or forward, and fracture of the posterior or anterior lip of the tibia or fracture of the shaft of the fibula accompanies the diastasis.

In any event, it is imperative that the mortise be restored to its normal width. This cannot be done successfully by closed treatment. Even with the foot held in marked equinus, thus permitting the narrow portion of the talus to lie in the mortise, external pressure alone does not accurately maintain joint width. Dorsiflexion of the ankle may be impaired after immobilization in the equinus position, thus adding further functional difficulties to those certain to follow the inadequate reduction.

These observations have been appreciated for some time, and open reduction for this injury is rather widely practised.[1, 3, 4] "Stove-bolt" techniques and other more complicated procedures have not been necessary in our experience. Accurate reduction and firm maintenance can be accomplished by means of screw fixation across the joint, using a lateral approach. After the fibula has been exposed at the level of the inferior tibiofibular

FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 5. A. F., male, aged forty-two years, had an inferior tibiofibular diastasis.

Fig. 5-B: Postoperative roentgenograms. The ankle was symptom-free eleven weeks following injury. Slight oedema was still present at that date.

joint, the diastasis is reduced by external pressure. A screw is accurately placed through the fibula, across the joint, and well into the tibia. It crosses the joint at an angle, thereby reducing direct strain and eliminating the tendency of the strain on the screw to strip loose the bony threads. A short leg cast is applied and is worn for six weeks. The foot and ankle are immobilized in neutral position. Weight-bearing is begun gradually after the third week. A normal ankle may be expected within twelve weeks from the time of injury (Case 5).

It is equally important to recognize tibiofibular diastasis, when this injury is associated with other ankle trauma. Treatment of associated fractures is not enough. The mortise must be restored and firmly stabilized by internal fixation until healing is complete. Only by this means can full functional recovery be expected.

COMPRESSION FRACTURES OF THE DISTAL END OF THE TIBIA

Compression or "explosion" fractures result from force driving the talus upward and into the distal tibial diaphysis. Extensive comminution and destruction of the distal tibial articular surface usually occur. The articular cartilage covering the superior surface of the talus may likewise be badly damaged, even though the bone itself remains intact. Closed reduction is notoriously ineffective with these injuries. Many orthopaedic surgeons, disappointed by any type of reconstructive fracture therapy, resort to primary ankle arthrodesis.

Symptom-free motion can be preserved in many of these cases, if the surgeon will utilize the correct operative techniques. It is necessary first to recognize that cancellous, diaphyseal bone is injured, and that there is actually compression of bony tissue. As the comminuted fragments of bone with their attached articular cartilage are repositioned, dead spaces persist. One cannot, then, expect these fragments to remain and heal in normal position unless firm and continued distraction is maintained across the joint. This distraction must be initiated prior to open restoration of the fragments to normal position. It must be maintained without interruption during the operation, and throughout the first five or six postoperative weeks, until sufficient healing has occurred to maintain the position of the fragments and the width of the joint. These technical requisites are accomplished by dual-pin traction. Two Steinmann pins are placed through the tibial shaft above the fracture site. A third pin is inserted through the os calcis. The extremity is then placed in a fracture-reduction frame and firmly distracted. After the frame and pins have been draped out of the operative field, and with the distraction maintained, the ankle is approached through the anterior incision previously described. The major fragments are properly aligned and the articular surface is reconstructed. Fixation is accomplished by vitallium screws or suture material. Thorough pressure irrigation with saline solution washes out small detached bits of bone and cartilage. Badly shredded bits of attached articular cartilage are removed with a scalpel. After primary closure, sterile dressings are placed over the incision. A circular cast is applied from the knee to the toes. The pins are firmly incorporated with the initial distraction undisturbed. As a further means of fixation, external rods may be connected between the pins. When the plaster has set sufficiently to maintain position, the leg is removed from the traction frame.

The original cast remains undisturbed for six weeks. At that time it is removed and the pins are withdrawn. Physiotherapy and active motion without weight-bearing are then begun. At the end of the tenth week, gradual weight-bearing is allowed. Crutches are discarded twelve to fourteen weeks after injury (Case 6).

The author has utilized this method of surgical reduction under fixed distraction in treating compression fractures of all major joints. It offers several evident advantages over the conventional methods of management. A surprising degree of restoration of function frequently follows its use in even the most severe compression fractures of the ankle joint.

FIG. 6-A

FIG. 6-B

Case 6. J. W., male, aged forty-two years, had a fracture of the tibia into the ankle joint, with displacement.

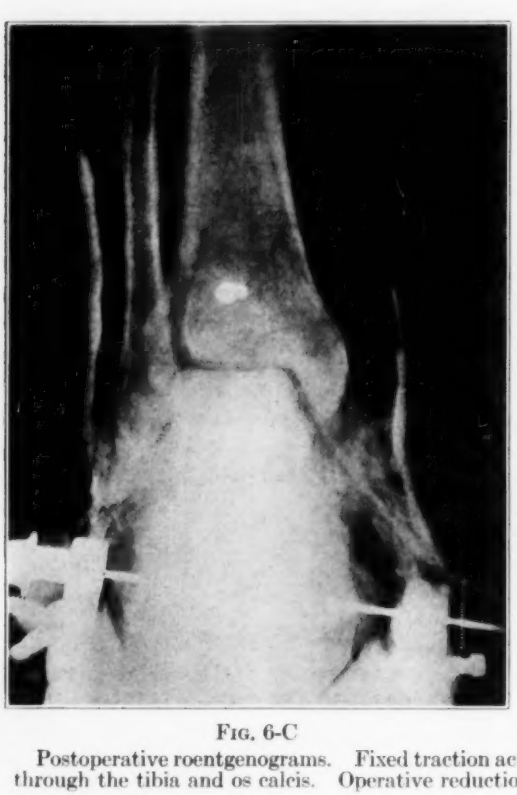

FIG. 6-C

FIG. 6-D

Postoperative roentgenograms. Fixed traction across the joint was maintained by Steinmann pins through the tibia and os calcis. Operative reduction was carried out under traction.

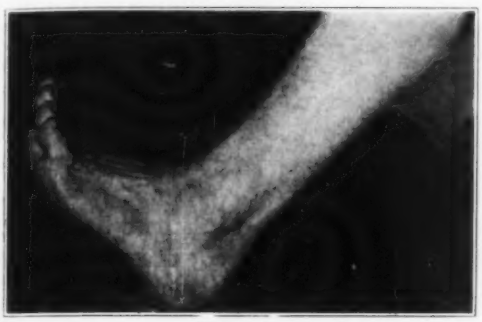

FIG. 6-E

FIG. 6-F

Eight months following injury. These photographs were taken after the patient had completed eight hours of work, standing on concrete. Some limitation of ankle motion persists, and the patient complains of discomfort during weather changes. The result at this time is functionally superior to ankle fusion, and the patient is improving.

FRACTURES OF THE LOWER TIBIAL SHAFT, EXTENDING INTO THE ANKLE JOINT

Occasionally spiral and oblique fractures of the lower tibia extend into the ankle joint. When displacement with joint derangement has occurred, open reduction with screw fixation offers a most satisfactory means of management. The same incision used to expose the lower shaft can be extended to expose the medial malleolus and medial or anterior aspect of the ankle joint. Accurate alignment and stability of fragments can thus be assured. In this way the ankle fracture, often overshadowed in importance by proximal fractures, is not neglected.

GENERAL CONSIDERATIONS

We have been fortunate in seeing most of these ankle fractures a very short time after injury. When the patient's general condition permits it, surgery is carried out at once.

A meticulous, preoperative, soap-and-water preparation of the skin is performed by either the surgeon or his surgical scrub nurse; this is followed by an alcohol and ether rinse. Spinal anaesthesia induced by heavy pontocaine hydrochloride is used routinely, unless contra-indications exist. A pneumatic tourniquet of the Campbell-Boyd type, inflated to twelve pounds pressure, is also routinely used. High-speed machinist's drill points of seven sixty-fourths of an inch gauge with Sherman-type vitallium screws of proper size constitute the basic fixation equipment. A wide selection of both drill points and screws should be on hand to meet any mechanical problem encountered. A minimum quantity of suture material is buried; either fine chromic catgut or silk is used. In every case, roentgenograms in two views are taken in the operating room before wound closure. A light circular cast is applied over a thin wrapping of sterile sheet-wadding. With immediate, sustained postoperative elevation, and early, vigorous, active movement of the toes, splitting of the cast is rarely necessary. We have had no postoperative infections in either the simple or compound cases comprising this study.

When the ankle is badly swollen on admission, pressure dressings are applied for one or more days, until suitable operative conditions prevail. It is considered advisable to operate at the earliest possible opportunity.

SUMMARY AND CONCLUSIONS

For the past three years, all fractures of the ankle, with displacement, coming under the author's care, forty-six in number, have been treated by primary open reduction. This departure from conventional treatment was not necessarily an admission of failure with closed methods. Rather it was a clinical attempt to evaluate, and, if possible, simplify and improve open technique. It was soon evident that functional recovery following ankle fractures depended primarily upon the application of accepted orthopaedic princi-

ples of: (1) accurate restoration of the articular surfaces of the tibia and fibula, and (2) firm ankle-joint stability. An accurate knowledge of the normal and traumatic anatomy of the ankle joint is indispensable to fulfillment of these two principles. The functions of ligamentous structures passing from the malleoli to the tarsus and of those between the inferior ends of the tibia and fibula deserve consideration equal to that focused upon the adjacent bony structures. Displaced tendons adjacent to the malleoli may also present obstacles.

Primary open reduction permits a more complete fulfillment of the two basic requisites of treatment. In many cases, it provides the only means whereby these two criteria can be met. Additional advantages offered by open treatment are immobilization of the ankle in neutral, weight-bearing position in all cases, early weight-bearing in plaster, and less extensive or prolonged cast fixation. The net result of these advantages is more rapid and usually more complete functional recovery. Weighed against these advantages are the dangers of operative infection, and the lack of necessary technical skill to administer properly the open treatment. The former of these two objections would not seem sufficient to withhold surgery, where a better result could thus be expected.

In conclusion, it is the author's opinion that primary open reduction of ankle fractures has an increasing field of usefulness, and merits wider popularity than it at present enjoys.

REFERENCES

1. Alldredge, R. H.: Diastasis of the Distal Tibiofibular Joint and Associated Lesions. J. Am. Med. Assn., CXV, 2136, 1940.
2. Alldredge, R. H.: Fractures about the Ankle Joint. New Orleans Med. and Surg. J., XCV, 414, 1943.
3. Burns, B. H.: Diastasis of the Inferior Tibio-fibular Joint. Proc. Royal Soc. Med., XXXVI, 330 (Sect. of Orthop., p. 24), 1943.
4. Darrach, William: Fractures around the Ankle Joint. New England J. Med., CCXXVI, 333, 1942.
5. Gatellier, Jean: The Juxtoretroperoneal Route in the Operative Treatment of Fracture of the Malleolus with Posterior Marginal Fragment. Surg. Gynec. Obstet., LII, 67, 1931.
6. Gillettee, E. P.: Fractures. About the Ankle. Industrial Med., XII, 160, 1943.
7. Henderson, M. S., and Stuck, W. G.: Fractures of the Ankle: Recent and Old. J. Bone and Joint Surg., XV, 882, Oct. 1933.
8. Kimberley, A. G.: Malunited Fractures Affecting the Ankle Joint. With Special Reference to Twenty-Two Cases Treated by Arthrodesis. Surg. Gynec. Obstet., LXII, 79, 1936.
9. Lee, H. G., and Horan, T. B.: Internal Fixation in Injuries of the Ankle. Surg. Gynec. Obstet., LXXVI, 593, 1943.
10. Lewis, R. W., and Graham, W. C.: Secondary Osteoarthritis following Fractures of the Ankle. Am. J. Surg., XLIX, 210, 1940.
11. Lounsbury, B. F., and Metz, A. R.: Lipping Fracture of Lower Articular End of Tibia. Arch. Surg., V, 678, 1922.
12. Meekison, Murray: Personal communication.
13. Nelson, M. C., and Jensen, N. K.: The Treatment of Trimalleolar Fractures of the Ankle. Surg. Gynec. Obstet., LXXI, 509, 1940.
14. Picot, Gaston: L'intervention sanglante dans les fractures malléolaires. J. de Chir., XXI, 529, 1923.

MARCH FRACTURE

A Statistical Study of Forty-Seven Patients

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March fracture is a fissure fracture due to stress, which most commonly occurs in the second, third, or fourth metatarsal bones, but may occur elsewhere. It is not produced by a single injury or accident. The etiology is represented by a combination of external and intrinsic circumstances which weaken the forefoot. Roentgenograms made before healing begins may show no evidence of fracture. In the later stages, callus formation and a fracture line are usually found. If no treatment is given, angulation, displacement, and excessive callus formation may occur.

This study of march fracture in soldiers is of value, because it correlates the attending circumstances in detail. The end results reported were made after a long follow-up; in certain instances a year had elapsed from the date of onset of symptoms. We discovered that many accepted concepts were disproved; that our patients had serious disability which tended to be recurrent and prolonged. In fact many were lost to the combat unit permanently.

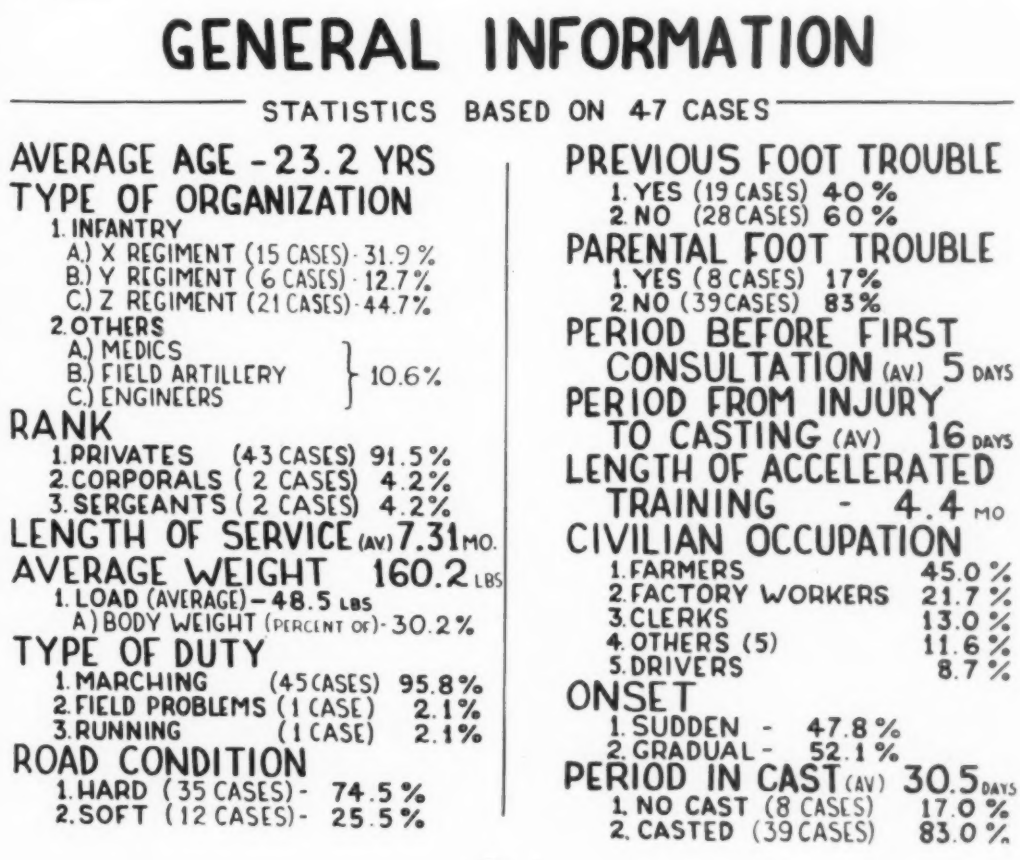
GENERAL INFORMATION
STATISTICS BASED ON 47 CASES
AVERAGE AGE - 23.2 YRS
TYPE OF ORGANIZATION
1. INFANTRY
A.) X REGIMENT (15 CASES) - 31.9 %
B.) Y REGIMENT (6 CASES) - 12.7 %
C.) Z REGIMENT (21 CASES) - 44.7 %
2. OTHERS
A.) MEDICS
B.) FIELD ARTILLERY } 10.6 %
C.) ENGINEERS
RANK
1. PRIVATES (43 CASES) 91.5 %
2. CORPORALS (2 CASES) 4.2 %
3. SERGEANTS (2 CASES) 4.2 %
LENGTH OF SERVICE (AV) 7.31 MO.
AVERAGE WEIGHT 160.2 LBS
1. LOAD (AVERAGE) - 48.5 LBS
A) BODY WEIGHT (PERCENT OF) - 30.2 %
TYPE OF DUTY
1. MARCHING (45 CASES) 95.8 %
2. FIELD PROBLEMS (1 CASE) 2.1 %
3. RUNNING (1 CASE) 2.1 %
ROAD CONDITION
1. HARD (35 CASES) - 74.5 %
2. SOFT (12 CASES) - 25.5 %
PREVIOUS FOOT TROUBLE
1. YES (19 CASES) 40 %
2. NO (28 CASES) 60 %
PARENTAL FOOT TROUBLE
1. YES (8 CASES) 17 %
2. NO (39 CASES) 83 %
PERIOD BEFORE FIRST CONSULTATION (AV) 5 DAYS
PERIOD FROM INJURY TO CASTING (AV) 16 DAYS
LENGTH OF ACCELERATED TRAINING - 4.4 MO
CIVILIAN OCCUPATION
1. FARMERS 45.0 %
2. FACTORY WORKERS 21.7 %
3. CLERKS 13.0 %
4. OTHERS (5) 11.6 %
5. DRIVERS 8.7 %
ONSET
1. SUDDEN - 47.8 %
2. GRADUAL - 52.1 %
PERIOD IN CAST (AV) 30.5 DAYS
1. NO CAST (8 CASES) 17.0 %
2. CASTED (39 CASES) 83.0 %

FIG. 1

Statistics related to etiology, onset, and circumstances pertaining to soldiers with march fracture.

FIG. 2

Atavistic foot with varus of the first, second, third, and fourth metatarsals, and hypertrophy of the medial side of the second only. If the mid-line of the foot is used, there is no actual shortening of the first metatarsal; but if the second (varus) metatarsal line is used, the first metatarsal appears to be longer.

An early diagnosis of march fracture depends, first, on the history, and, second, on the result of palpation along the dorsal aspect of the metatarsal shafts. The roentgenographic examination must be repeated, if symptoms persist, until signs of healing or a fracture line appear.

The general information in Figure 1 was obtained by use of a routine questionnaire.

From these facts it appears that the average soldier in this group is young; he has not had a sedentary life; he may or may not have had previous ordinary foot complaints;

PHYSICAL FINDINGS

BASED ON 46 CASES

LENGTH 1ST METATARSAL (ESTIMATED)

1. SHORT	(30 CASES)	65.2%
2. EQUAL	(9 CASES)	19.5%
3. LONG	(7 CASES)	15.2%

STRUCTURE

1. MEDIUM	(25 CASES)	54.3%
2. HEAVY	(15 CASES)	32.6%
3. LIGHT	(6 CASES)	13.0%

POSTURE

1. CAVUS	(15 CASES)	32.5%
2. NORMAL	(23 CASES)	50.0%
3. POOR	(8 CASES)	17.4%

WHICH FOOT

1. RIGHT	(20 CASES)	43.5%
2. LEFT	(26 CASES)	56.5%

FIG. 3

he had been in the Army for an average of seven months; and he had been carrying heavy packs on hard-surfaced roadways, often with speed as an objective (Fig. 1). Our data showing gradual onset in 52 per cent. of cases is misleading, because the soldier knows the date and stage of the march in which the symptoms began.

The congenital foot structure has been frequently described as an underlying basis for march fracture. The atavistic foot (Fig. 2) as described by Morton and by Watson-Jones, in discussing march fracture, has either varus of the first metatarsal, shortening of the first metatarsal, or increased flexibility of the first metatarsocuneiform joint, or all of these characteristics as predisposing factors. Most of our patients had a shortening of the first metatarsal bone, measurable in the roentgenograms. (These roentgenograms were not made with the patient standing.) This shortening was measured from a line at right angles to the axis of the second metatarsal bone. The first metatarsals measured shorter in 56 per cent. of the roentgenograms by this method, and were in varying degrees of abnormal varus. The presence of varus of the second metatarsal decreased the ratio of shortened first metatarsal bones, when the long axis of this bone was used in measurement. A line at right angles to the long axis of the foot shadow will increase this ratio of short first metatarsals, as described by Lewin. An estimate of this shortening may be obtained by pressure on the sole under the metatarsal heads, while the first and second toes are flexed. Because of swelling and stiffness, it was frequently impossible to flex passively the second metatarsophalangeal joint sufficiently. The high incidence of normal foot posture was also a surprise (Fig. 3).

The presence of varying degrees of pes cavus in 32.5 per cent. of instances was unexpected. These feet varied from the high type of rigid bony cavus to estimated moder-

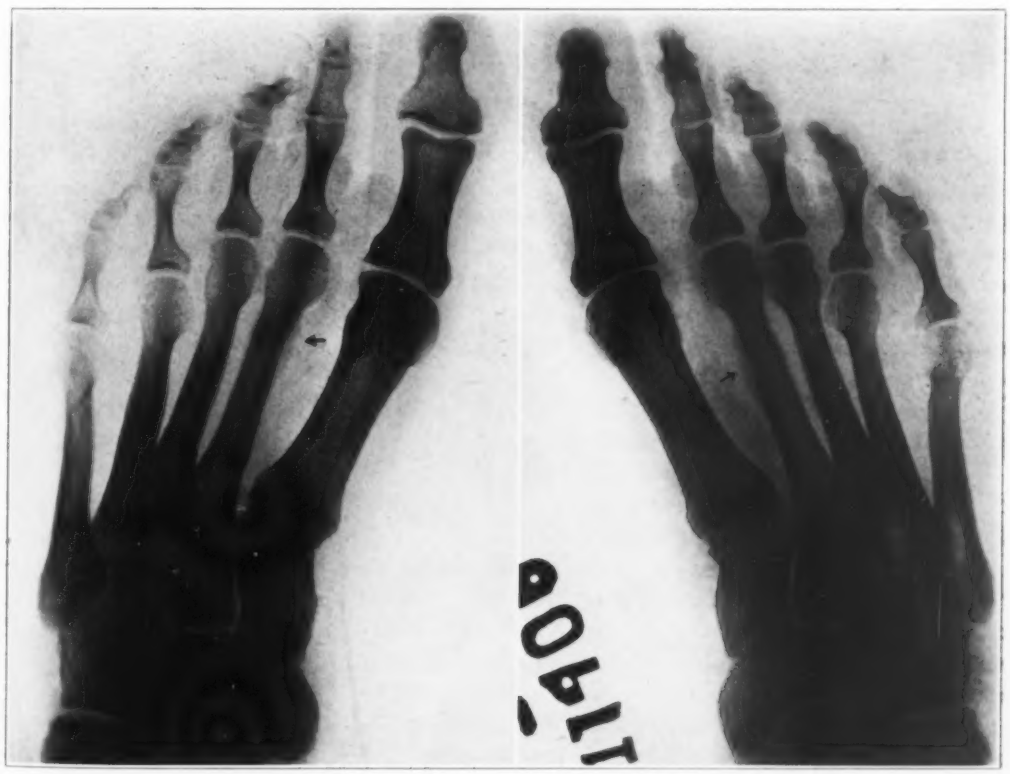

FIG. 4-A FIG. 4-B

Bilateral fracture of the second metatarsals. The subperiosteal callus only is visible in the printed reproductions.

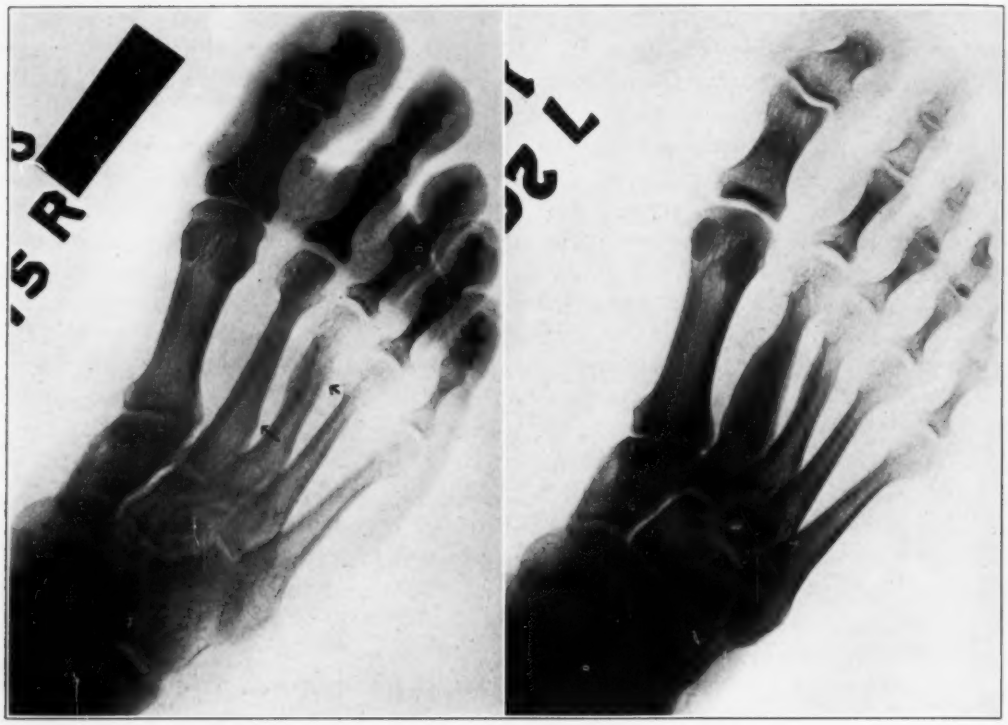

FIG. 5-A

FIG. 5-B

Fig. 5-A: March 26, 1943. Two metatarsal fractures in the same foot. The proximal fracture in the second metatarsal is recent, the distal fracture in the third metatarsal is older. The recent fracture went untreated.

Fig. 5-B: July 26, 1943. Four months later there is massive hypertrophy of the second metatarsal.

ately high long arches, but with abnormally tight or contracted plantar fasciae. The latter types may appear within normal limits on inspection and before careful manual palpation, either standing or non-weight-bearing. One not trained in foot examination does not observe these findings. The predisposition, through congenital structure of the foot, is again indicated by the bilateral march fractures (Figs. 4-A and 4-B), and the occurrence of refracture or multiple fractures in one foot (Figs. 5-A, 5-B, and 6).

One patient had the three central metatarsals fractured six months before our first examination; he had carried on in spite of his pain (Fig. 7).

Since we do not know the incidence of the congenital features in the so-called normal, asymptomatic soldiers, we cannot properly stress their contribution to the etiology. It is no doubt a basic etiological factor in the occurrence of march fractures.

We have found the results of roentgenographic study of march fractures to be very striking (Fig. 8). The importance of repeated roentgenographic examinations is demonstrated by Figures 9-A, 9-B, and 9-C.

The physiological process of fracture healing, either in absorption at the fracture line or appearance of subperiosteal callus, is the best indicator in arriving at a proved roentgenographic diagnosis. If the examination is definitely suggestive, rest is indicated until roentgenograms can be repeated periodically. Some soldiers have been permitted to remain on combat duty for weeks, because the initial film was negative. In one instance the diagnosis was not made until the third film. In 8.5 per cent. of the patients, a fracture line did not appear at all (Fig. 12); only callus formation could be seen in the films in these cases. Since healing by subperiosteal callus formation has not been dissimilar to the others with a visible fracture line, we assumed the presence of a fracture. Whether or not subperiosteal hemorrhage alone is present in a small percentage of patients is unde-

FIG. 6

FIG. 7

Fig. 6: Healing in fractures of the second and third metatarsals of apparently the same duration (four months). They had been untreated and were painful. The first metatarsal is atavistic.

Fig. 7: Fractures of three metatarsals. Still painful after six months. These probably occurred on the second fifteen-mile hike (not included in present series). The patient has a marked atavistic forefoot and wears size 15½ EE shoe. He received no treatment, and continued duty after one report to the infirmary. Discharge from the Army is recommended.

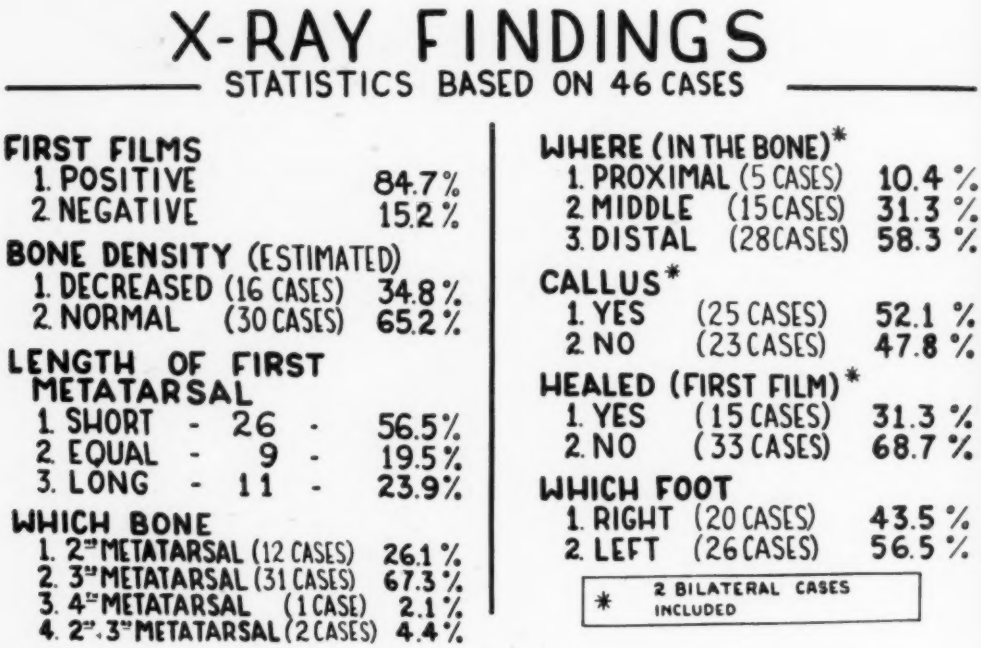
X-RAY FINDINGS
STATISTICS BASED ON 46 CASES
FIRST FILMS
1. POSITIVE 84.7%
2. NEGATIVE 15.2%
BONE DENSITY (ESTIMATED)
1. DECREASED (16 CASES) 34.8%
2. NORMAL (30 CASES) 65.2%
LENGTH OF FIRST METATARSAL
1. SHORT - 26 - 56.5%
2. EQUAL - 9 - 19.5%
3. LONG - 11 - 23.9%
WHICH BONE
1. 2ND METATARSAL (12 CASES) 26.1%
2. 3RD METATARSAL (31 CASES) 67.3%
3. 4TH METATARSAL (1 CASE) 2.1%
4. 2ND, 3RD METATARSAL (2 CASES) 4.4%
WHERE (IN THE BONE)*
1. PROXIMAL (5 CASES) 10.4%
2. MIDDLE (15 CASES) 31.3%
3. DISTAL (28 CASES) 58.3%
CALLUS*
1. YES (25 CASES) 52.1%
2. NO (23 CASES) 47.8%
HEALED (FIRST FILM)*
1. YES (15 CASES) 31.3%
2. NO (33 CASES) 68.7%
WHICH FOOT
1. RIGHT (20 CASES) 43.5%
2. LEFT (26 CASES) 56.5%
* 2 BILATERAL CASES INCLUDED

FIG. 8

termined. We have not made a diagnosis of "march foot" without roentgenographic confirmation, as has been done by Bush.

The estimation of bone atrophy in this study is of little value, because the roentgenographic intensity and other factors influencing roentgenographic density were not known nor compared with controls.

The persistence of severe pain and tenderness was accompanied in a few cases by massive callus formation (Fig. 10), resulting in enlargement of a large segment of the metatarsal shaft, with persistence of the fracture line in some instances. One of these patients, seen after three weeks, is shown in Figure 10. He was placed in a walking plaster for five weeks, with several weeks of light activity, but hypertrophy continued. Evidently these fractures were not solidly healed, or were *repeatedly refractured* at unknown intervals. This same patient later returned with fractures of the second and fourth metatarsals in the same foot.

In the study of our recheck films after immobilization in walking plasters, our attention was frequently called by the roentgenologist to the apparently increased callus formation. This did seem to be true. However, many of these patients were untreated for a variable initial time, during which they were sometimes very active, thus possibly laying the groundwork for large callus formations, regardless of the type of treatment subsequently used. Fortunately massive callus formation does not occur in all untreated cases.

Obviously the estimation of the state of healing from the roentgenographic standpoint was not necessarily borne out by clinical symptoms, and was of value only as a suggestion of the age of the fracture.

Prophylaxis

Shoes: The sole of the present training shoe soon becomes quite flexible, not only in the shank, but also throughout the whole forefoot. It frequently assumes a rocker curve when not worn, and in walking much dorsiflexion is permitted at the metatarsophalangeal joints. Difference of opinion exists as to the desirability of this suppleness in the sole. For ordinary walking it seems excellent; but, when a heavy pack is added, a

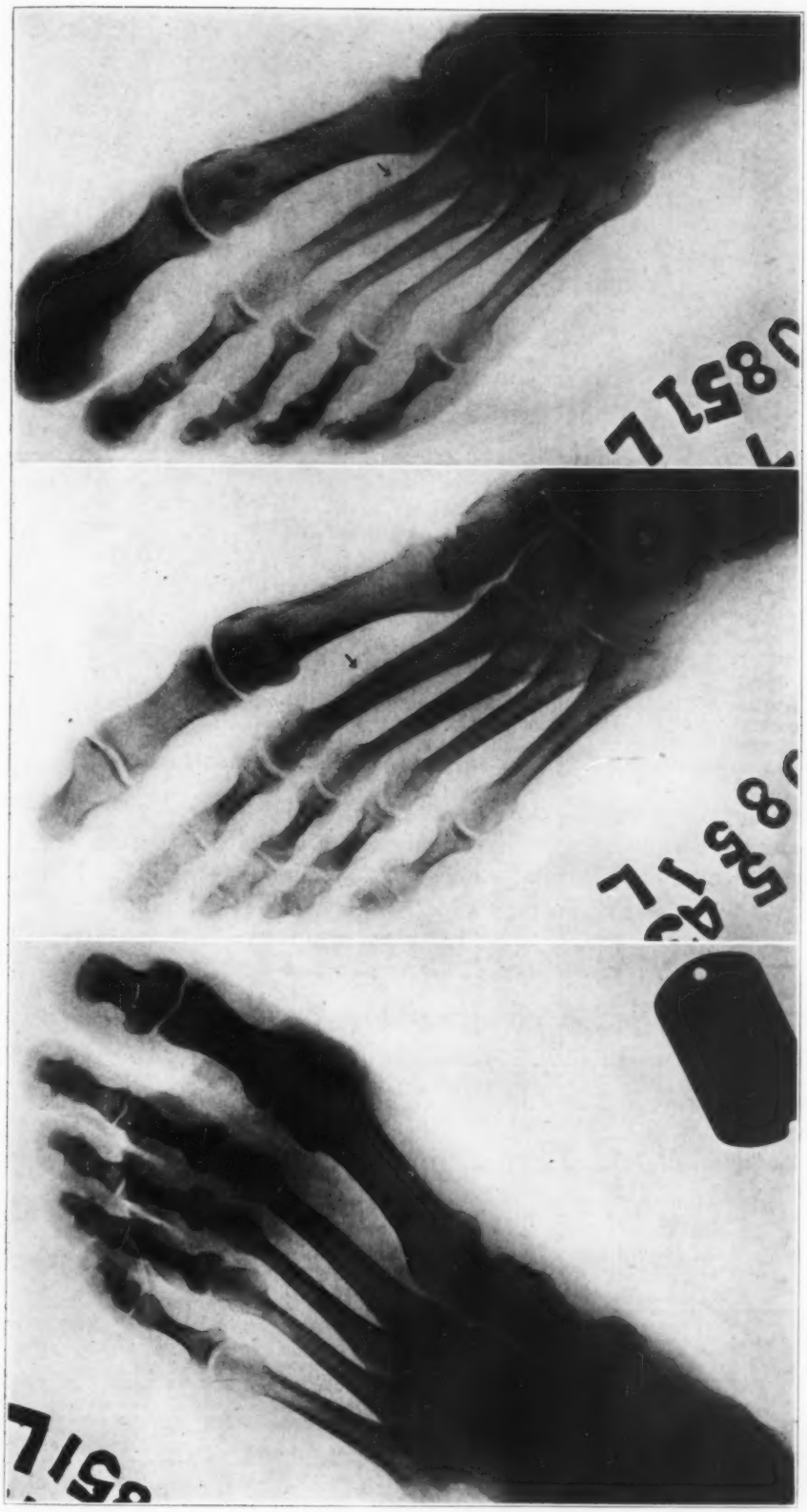

FIG. 9-A

March 24, 1943. The roentgenogram is negative for march fracture.

FIG. 9-B

April 5, 1943. Callus is beginning to form on the medial aspect of the second metatarsal. No fracture line is visible.

FIG. 9-C

May 7, 1943. The fracture line and callus are visible.

FIG. 10

Old healing fracture of the third metatarsal showing massive hypertrophy. The patient had been treated in the early stage with a walking cast for five weeks. After this roentgenogram was taken, he was treated for two months, part of the time in bed. He has returned since with fractures also of the second and fourth metatarsals, which had occurred when he had attempted field activity with a pack.

more rigid sole offers protection against excessive localized bending stress. We have not found short shoes to be an obvious factor as described by Bush. In our experience short shoes of serious degree are so uncomfortable that strenuous activity is automatically limited.

END RESULTS

VARIABLE PERIODS AFTER ONSET: MOST CASES ABOUT 7 MONTHS; SOME AS MUCH AS 11 MONTHS.

1. COMPLETE RECOVERY:
   - A) YES (10 CASES) 20.8%
   - B) NO (SOME COMPLAINT) (38 CASES) 79.1%

2. RECLASSIFIED TO LIMITED SERVICE:
   - A) YES (11 CASES) 22.8%
   - B) NO (37 CASES) 77.1%

3. TYPE OF DUTY AFTER:
   - A) INFANTRY
     - 1) YES (27 CASES) 56.3%
     - 2) NO (21 CASES) 43.7%

TABLE BASED ON 47 CASES PROPORTION	NO CASES	%
PREVIOUS TROUBLE WITH COMPLETE RECOVERY	2	4.3
PREVIOUS TROUBLE WITH INCOMPLETE RECOVERY	14	29.8
NO PREVIOUS TROUBLE WITH COMPLETE RECOVERY	8	17.0
NO PREVIOUS TROUBLE WITH INCOMPLETE RECOVERY	23	48.9

TABLE NON-CASTED (8 CASES) PROPORTION	NO CASES	%
PREVIOUS TROUBLE WITH INCOMPLETE RECOVERY	2	25.0
NO PREVIOUS TROUBLE WITH INCOMPLETE RECOVERY	5	62.5
NO PREVIOUS TROUBLE WITH COMPLETE RECOVERY	1	12.5

FIG. 11

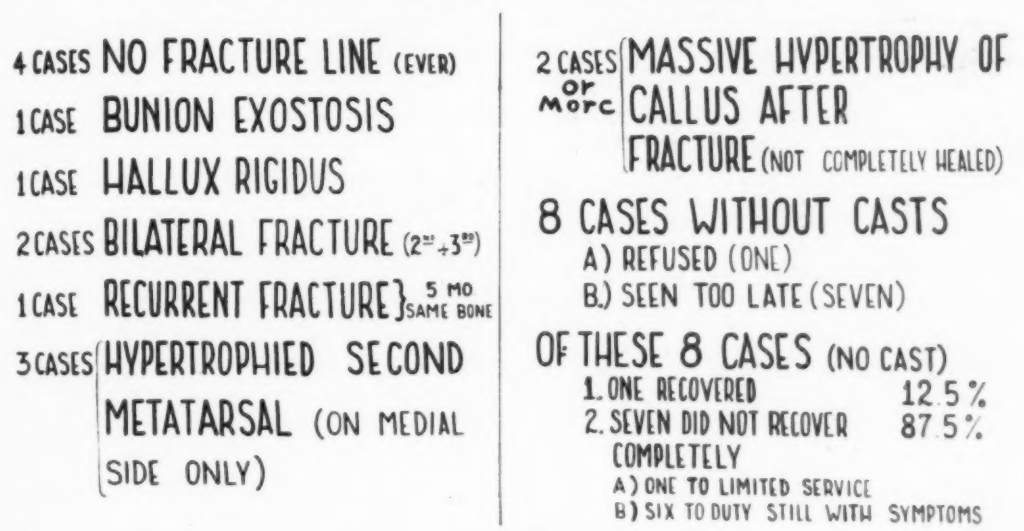
MISCELLANEOUS REMARKS
4 CASES NO FRACTURE LINE (EVER)
1 CASE BUNION EXOSTOSIS
1 CASE HALLUX RIGIDUS
2 CASES BILATERAL FRACTURE (2nd + 3rd)
1 CASE RECURRENT FRACTURE } 5 MO SAME BONE
3 CASES HYPERTROPHIED SECOND METATARSAL (ON MEDIAL SIDE ONLY)
2 CASES OR MORE MASSIVE HYPERTROPHY OF CALLUS AFTER FRACTURE (NOT COMPLETELY HEALED)
8 CASES WITHOUT CASTS
A) REFUSED (ONE)
B) SEEN TOO LATE (SEVEN)
OF THESE 8 CASES (NO CAST)
1. ONE RECOVERED 12.5%
2. SEVEN DID NOT RECOVER COMPLETELY 87.5%
A) ONE TO LIMITED SERVICE
B) SIX TO DUTY STILL WITH SYMPTOMS

FIG. 12

Training: We consider the problem of training most important. Foot and general conditioning can be obtained as effectively on soft or natural ground. This difference is readily noted by the normal individual, when he compares the strain of hiking on hard pavements with that encountered on soft surfaces. Combinations of training should be arranged to properly adjust these factors. Peak training should not be attained too soon or sustained too long, if the optimum foot seasoning is desired.

Treatment: The treatment of march fracture is passed over lightly and optimistically by most writers. We have applied a short walking plaster, usually unpadded. These plasters remained on from three to five or more weeks (Fig. 1). We continued the plaster immobilization until at least six weeks after the date of fracture. Gradual weight-bearing was instituted, with a felt support for the central metatarsal or first metatarsal head held by a tape boot or by foot taping. *In the plaster*, most patients returned to light duty with their organizations. Many did a good deal of restricted walking and much weight-bearing without pain. Later, metatarsal bars were added to the shoes when the patient complained of continued pain.

These patients returned to full duty very slowly, many not at all. Even after the end results were tabulated (Fig. 11), we continued to receive complaints.

The patients have returned to our Clinic for unexpectedly long periods, and in a large percentage of cases, have continued to complain of foot pain, swelling, or limp, especially on hiking, as long as we could follow them. They appeared to do little better than did unrecognized, or late untreated cases, or the few patients who, though seen early, were untreated by choice. These poor results appeared despite the fact that weight-bearing in plaster is one of the accepted forms of treatment.

Not satisfied with our results, a different form of treatment has been adopted. In a few more recent and unreported patients, as well as those of the old series, with complications, who have returned, we have insisted upon absolute freedom from weight-bearing. If two weeks or less has elapsed, a plaster is applied for three weeks, with no weight-bearing on the plaster. A high-vitamin diet is given empirically. At the end of the plaster period, or immediately, if the duration is over two weeks, warm whirlpool baths and massage treatment are given daily, and continued without weight-bearing *until soreness disappears.* Convalescent walking and ward activity are gradually increased, if

pain is not produced. We have no real follow-up on this method yet. More complete early cessation of pain and tenderness seems to be resulting. It is possible that a condition, produced by prolonged overexertion and irritation with foot decompensation, may require absolute rest, rather than the usual treatment given simple traumatic metatarsal fractures. Our results favor this change of treatment.

We believe that the good results reported by other authors, who have used various forms of accepted treatment, may be due to a mere routine follow-up over an insufficient period of time, and to a lack of knowledge of the actual type of duty to which the soldier returns.

CONCLUSIONS

There are many predisposing factors in march fractures, some of which may be controlled.

Initial roentgenographic examination is often negative and should be repeated. In 8.5 per cent. of the patients, no fracture line was visible at any time to accompany callus formation.

At present we feel that early diagnosis and treatment by absolute freedom from weight-bearing until soreness disappears may give the best results.

The type of treatment and the end results, reported previously in the literature, have not been clearly described.

Our end results have been poor. We conclude that march fracture in soldiers is more serious than other reports have indicated.

In a future report we will present a series of cases treated with absolute rest.

REFERENCES

Bush, L. F.: March Foot (March Fracture). Its Early Diagnosis and Treatment. Bull. of U. S. Army Med. Dept., No. 68, 126, 1943.

Lewin, Philip: The Foot and Ankle. Their Injuries, Diseases, Deformities and Disabilities. Ed. 2. Philadelphia, Lea & Febiger, 1941.

Morton, D. J.: The Human Foot. Its Evolution, Physiology and Functional Disorders. New York, Columbia University Press, 1935.

Watson-Jones, R.: Fractures and Other Bone and Joint Injuries. Ed. 2. Baltimore, Williams and Wilkins Co., 1941.

MARCH FRACTURE

A Report of Three Hundred and Seven Cases and a New Method of Treatment

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It is a well-established fact that one of the infantryman's greatest assets is a pair of good feet, since he may be called upon to make forced marches for long distances over rough terrain, during inclement weather, and under other adverse conditions.

During World War I, "march fracture" of the foot was also known as "*pied forcé*", "Deutschländer's disease", "march foot", "*Fussgeschwulst*", *et cetera*.[2, 4, 5] Today, this same condition is also called "fatigue fracture" or "stress fracture".[7] Several interesting articles and unusual case reports have appeared in the American literature since our country entered the War.[1, 3, 6, 8, 10]

In the past nine months, at Camp Wolters, Texas, 307 cases of march fracture of the foot have been seen. All types of men in various grades of physical development have been examined. It is natural to expect to see many patients with foot complaints, because of the rigorous basic training the newly enlisted man has to undergo. Among the more common syndromes seen was that of march fracture. Significantly enough, this condition was rarely seen prior to June 1942, at which time the tempo of the Infantry basic training was increased, and the so-called "speed march" and the prolonged march (sixteen to twenty miles) were introduced. Very soon afterward, this condition became much more prevalent. Since the caliber of men at that time and prior to June 1942 was practically the same, it is believed that the increased foot fatigue and the stress accompanying this type of march were the most vital factors in the production of the syndrome. This condition is not seen so frequently in branches of the Army other than the Infantry, since long marches and speed marches are not repeatedly performed during the training cycle.

The common picture seen in fractures of the foot is immediate loss of function, as a result of some sudden or direct violence. In contrast, an early march fracture causes only mild discomfort, since some soldiers with march fracture frequently walk around with very little pain or disability, and never appear on sick call. However, in other soldiers, similar fractures have been more or less incapacitating.

In a recent issue of the *Military Surgeon* [6], an open letter to the Editor regarding Bush's article on march fracture states:

> "Regarding the subject of 'March Fracture' . . . may we in field units express an opinion? We have on several occasions been told by our own orthopedic consultants that our men with march fractures could be expected to make a complete recovery, be able to do full duty and suffer no symptoms as a result of their injury. Whether or nor Major Bush intended to imply this I do not know. However, such is not the case. Most of these men do not make good infantry soldiers, once they have suffered such a fracture. Their ability to walk great distances is gone, because of the pain in the foot. We have kept no statistics with which to prove our point, but our general impression from seeing a number of cases before, during and after treatment for march fracture is that perhaps it would be a wise practice never to attempt to put one of these men back in the infantry. Almost invariably such men become a detriment to their organization and removal of their casts or splints is followed by a long series of efforts to get them out of the division."

We beg to differ with the conclusion drawn, and can show by our series of cases and by our method of treatment that these trainees with march fracture recover completely, make good infantry soldiers, and finish all the required prolonged marches and speed hikes, as ably as the soldier who has not had a march fracture.

FIG. 3

Callus mass about the left second metatarsal twenty days following onset of symptoms.

FIG. 2

Early periosteal reaction of the right second metatarsal ten days following the onset of symptoms.

FIG. 1

Fracture of the left third metatarsal three days after onset of symptoms.

FIG. 4-A

April 4, 1943. Anterior view, showing callus formation of the shaft of the right third metatarsal twelve days after onset of symptoms.

FIG. 4-B

August 5, 1943. Anterior view four months later, showing healed fracture.

FIG. 4-C

December 9, 1943. Anterior view eight months after onset of symptoms.

ETIOLOGY

We believe that, etiologically, this type of fracture is due to direct bone stress, following the complete fatigue and exhaustion of the supporting structures of the foot, which include the muscles, ligaments, and fascia. This theory is in accordance with similar ideas previously expressed by other authors.[7, 9] We do not agree with Berkman that a stiff-soled army shoe is a predisposing factor in the development of this fracture, since most of our cases occurred in soldiers between the fortieth and the sixtieth day of their training, at which time the shoes are well "broken in". However, we do acknowledge that a long march is a definite etiological factor.

SYMPTOMS

The soldier first notices pain in the involved foot during a long march or a "speed march". The pain is of a dull, aching, burning character, and is rarely severe enough to cause him to "fall out" of a hike. As the soldier continues to perform his various duties during the next few days or weeks, the pain gradually increases in intensity and severity, and a limp develops. The progression of this chain of events continues with increased severity, until swelling of the dorsum of the foot becomes definitely noticeable, at which time the soldier usually appears on sick call. This first appearance, as was previously mentioned, may not occur for several days to several weeks after symptoms are noticed.

PHYSICAL FINDINGS

On examination, the patient walks with a definite foot limp on the involved side, primarily because of pain on weight-bearing. He walks with a rigid forefoot held either inverted or everted, depending upon the metatarsal fractured. The dorsum of the foot is definitely swollen; the swelling is most pronounced at the fracture site, and obliterates spaces normally seen between the extensor tendons. At times, there is a definite palpable increase in local heat. The most constant finding is localized tenderness at the fracture site. Crepitus is very rarely elicited. Other signs frequently present are pain on forced plantar flexion or on traction on the corresponding toe.

ROENTGENOGRAPHIC FINDINGS

A roentgenogram of the suspected foot, taken two or three days after the onset of symptoms, may be completely negative for fracture. In other instances, if the roentgenogram is taken two or three days after the onset, and is read when dry, with the aid of a hand magnifying lens, a hairline fracture may be seen, involving only the cortex of the shaft of the metatarsal (Fig. 1). The fracture line is most frequently seen at the distal end of the shaft, but it may be present in the mid-shaft. Usually by the tenth day after the initial complaint, the roentgenogram reveals evidence of a fracture line or some early callus formation (Fig. 2). The fracture line may be regular and transverse in character, or may be jagged or oblique. After three weeks, the callus is usually abundant and forms a spindle-shaped mass about the break (Fig. 3). A march fracture from the onset is usually an incomplete fracture, and, for this reason, there is rarely any loss of position or alignment of the fragments (Fig. 1). As the fracture becomes complete through continued weight-bearing, the position and alignment are probably maintained by the supporting callus. Four months after the development of a march fracture, union is so perfect that it is difficult to detect the site of the march fracture, unless previous films are present to aid in locating it (Figs. 4-A, 4-B, and 4-C). In our series, we were unable to prove definitely that the primary fracture site was present most often on the concave surface of the metatarsal, as contended by Hartley, but we agree with him that this is a fatigue or stress fracture.

STATISTICS

At this post, during the past nine months, we have seen and examined 307 cases of march fracture. Careful statistical data have been kept on all these cases. The youngest

TABLE I

Days of Training	No. of Cases
0– 19	31
20– 39	81
40– 59	103
60– 79	77
80– 99	13
100–120	2
Total	307

soldier in our series was eighteen years old, and the oldest, thirty-five. The weight of the patients varied from 100 to 215 pounds, and the height from five feet, three inches to six feet, two inches. From our studies, we have not found any correlation between age, height, and weight in the development of a march fracture. We also found that the condition occurred almost an equal number of times, in the right and left foot. March fracture developed in two soldiers on the first day of the training cycle. However, in most of the enlisted personnel in our series, this condition developed between the twentieth and sixtieth day of their training, at the time when the speed march and long march are first introduced. In only two soldiers did this condition develop in the last quarter of the training cycle.

The second metatarsal was most frequently involved (157 cases), although the third metatarsal was almost as frequently affected (136 cases). The first and fifth metatarsals are supposed to be only rarely if ever involved, yet we have three cases of march fracture involving the first metatarsal (Fig. 5), and another involving the fifth metatarsal (Figs. 6-A and 6-B). There were ten cases involving the fourth metatarsal.

An attempt was made to link this type of fracture with a constant or inconstant type of foot deformity. This was impossible, since this fracture was present in soldiers with pes planus, pes cavus, pronated foot, and also with an apparently normal foot. Careful histories failed to show any correlation between the soldier's previous occupation and the development of a march fracture. This condition, however, is rare in colored soldiers.

We have seen several unusual cases of march fracture. In one soldier, a march fracture of the second and fifth metatarsal bones developed at the same time,—on the twenty-ninth day of his training (Fig. 6-A). In another soldier, a march fracture of the second left metatarsal developed, and nineteen days later a fracture of his second right metatarsal. Still another soldier fractured his second left metatarsal on the thirty-ninth day of his training, his second right metatarsal on the forty-third day, and his third right metatarsal on the fifty-fourth day. Yet, after treatment, this latter soldier completed his basic training and was well enough to qualify as a full-duty infantryman. Recorded in our files is the case of another trainee in whom a march fracture of the third right metatarsal developed on his forty-fourth day of training, and a refracture of the same bone ninety-five days later.

TREATMENT

The treatment is not original, but has been used previously for fractures of the toes, bursitis between the heads of the metatarsals, and various other conditions of the foot.

Patients with a march fracture complain of pain during the push-off phase of the gait,—that is, when the weight is borne on the heads of the first, second, and fifth metatarsals, with the toes dorsiflexed and the heel off the ground. If during the gait the foot is held rigid, thus eliminating motion at the metatarsophalangeal joints, the pain is markedly decreased. In order to accomplish this same rigidity, a steel bar one-half of an inch to five-eighths of an inch wide, one-eighth of an inch thick, and six inches long is counter-

FIG. 6-B

FIG. 6-A

Anterior and lateral views of fracture of the left second and fifth metatarsals thirteen days after the onset of symptoms.

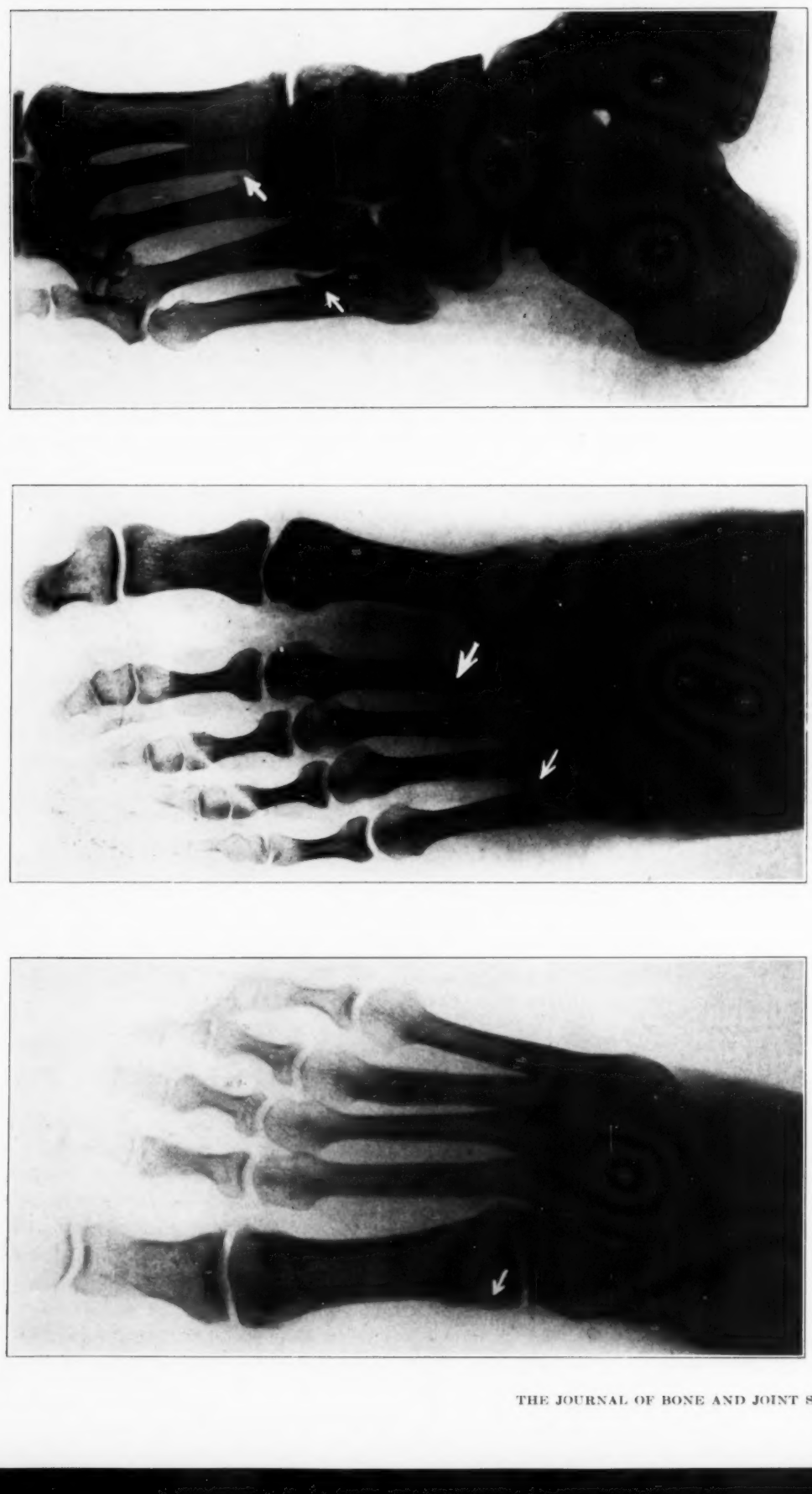

FIG. 5

Fracture of the base of the first metatarsal.

TABLE II

RECOVERY

Time Interval before the Application of the Bar	No. of Cases	Average Time Interval from Application of the Bar to Complete Recovery
17 days	3	71 days
14 days	4	73 days
7 days	33	65 days
5 days	37	55 to 61 days
1 day	68	47 days
Several hours	151	25 to 35 days
No delay	11	Sick furlough for 30 days

sunk into the sole of the shoe. Originally this bar was countersunk on the weight-bearing surface of the sole; but, as the sole wore down, the metal became more prominent, acted as a rocker, and caused discomfort. At present the steel bar is countersunk on the underside or non-weight-bearing surface of the sole, and is held in position by four rivets (See Figs. 7-A and 7-B).

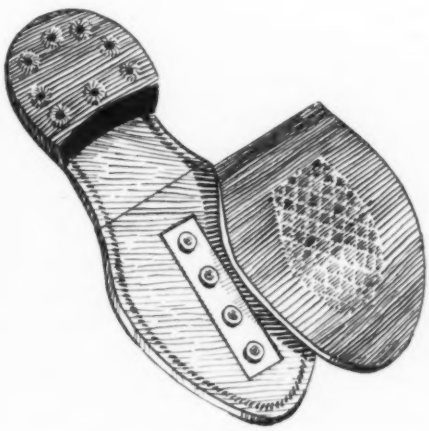

FIG. 7-A

FIG. 7-B

Showing bar in place on non-weight-bearing surface of the sole of the shoe.

The relief obtained by this means is very definite, and becomes more noticeable after several days,—that is, as soon as the patient becomes accustomed to walking with a stiff-soled shoe. In this way, the patient may continue the greater part of his basic training with very little handicap. Most patients continue with their full training and are rarely hospitalized.

Occasionally the patient is further relieved by placing a felt pad along the longitudinal arch, in order to redistribute the weight. The steel bar is kept in position for approximately four to five weeks, at which time the fracture has solidly healed. The metal bar can then be removed and used again.

Patients with march fracture of one foot are not hospitalized, but as soon as diagnosis is made clinically or roentgenographically they are sent to the Camp Shoe Repair Shop, with a requisition for a "march bar". Patients wait for their shoes to be repaired, and then report back to their companies for further training. In this way hospital days and training days are saved.

Table II shows the time interval between the application of the metal plate and the complete recovery. In the beginning of our series, much time was lost in having the

march bar countersunk into the sole of the shoe, but now, as soon as the diagnosis is made, the soldier has the metal plate countersunk on the non-weight-bearing surface of the sole of his shoe.

From this table, the conclusion can be drawn that the sooner the bar is applied, the sooner can complete recovery be expected. Eleven cases, or 3.6 per cent., did not respond to this type of treatment. These latter patients were given thirty-day sick furloughs, with instructions to continue weight-bearing on the injured foot as much as pain would allow. On return from furlough, these patients are usually fit for full duty.

SUMMARY

From this series of 307 cases of march fracture, certain pertinent conclusions can be drawn.

1. Prior to the introduction of "speed hikes" and prolonged marches in the curriculum of basic training, march fractures were rare entities. Soon after this change in the curriculum occurred, we commenced seeing this syndrome.

2. This pathological condition occurred in soldiers irrespective of age, height, weight, and general body build.

3. No usual or unusual deformities of the foot were associated with this condition.

4. One or more of the metatarsals may be involved at the same time, or at different times during the same training cycle.

5. There is no relation between pre-induction occupation and the development of a march fracture.

6. Contrary to general opinion, this condition does occur in the colored soldier, although not nearly so frequently as in the white soldier.

7. The treatment, as described in this paper, was found to be adequate enough to keep the soldier on duty without missing the greater portion of his training. After six to eight weeks, the soldier is able to perform his duties as well as the man who never had a march fracture.

8. The method of treatment described saves innumerable hospital and training days.

9. In our opinion, the treatment of a march fracture of the foot by immobilization in a plaster-of-Paris bandage, as described in the literature, is not indicated, since this is not a complete fracture, and there is no loss of position or alignment. Furthermore, rigid immobilization causes a bone and muscle atrophy of the involved foot and leg. When the plaster cast has been removed, it is necessary for the patient to receive physiotherapy over a period of several weeks before he can return to his normal duties. With our method of treatment, all this is obviated.

REFERENCES

1. Berkman, E.: Etiological Possibilities of March Fractures. J. Bone and Joint Surg., XXV, 206, Jan. 1943.
2. Breithaupt: Zur Pathologie des menschlichen Fusses. Med. Zeitung Berliner, XXIV, 169 und 175, 1855.
3. Bush, L. F.: March Foot (March Fracture). Its Early Diagnosis and Treatment. Bull. of U. S. Army Med. Dept., No. 68, 126, 1943.
4. Dodd, Harold: Pied Forcé or March Foot. British J. Surg., XXI, 131, 1933.
5. Elward, J. F.: March Foot. Am. J. Roentgenol., XXXVI, 188, 1936.
6. Hammond, Keith: March Fracture. (Correspondence) Military Surg., XCIII, 440, 1943.
7. Hartley, J. B.: "Stress" or "Fatigue" Fractures of Bone. British J. Radiol., XVI, 225, 1943.
8. Krause, G. R.: March Fracture. Radiology, XXXVIII, 473, 1942.
9. Straus, F. H.: Marching Fractures of Metatarsal Bones with Report of the Pathology. Surg. Gynec. Obstet., LIV, 581, 1932.
10. Sweet, H. E., and Kisner, W. H.: March Fractures. J. Bone and Joint Surg., XXV, 188, Jan. 1943.

INSUFFICIENCY FRACTURE OF THE CALCANEUS

Similar to March Fracture of the Metatarsal

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From the Station Hospital, Camp Wheeler, Georgia

An unusual and large series of fractures of the calcaneus of a distinct type has been seen in trainees at this Camp, as a result of "toughening up" the training program and fitting soldiers into better condition to withstand the rigors and demands of present-day warfare.

Little reference to this syndrome can be found in medical literature. March fracture of the calcaneus has been reported and mentioned, usually as the report of an unusual case, but not as a definite syndrome of frequent occurrence. The condition as a clinical entity is apparently not familiar to most medical officers and orthopaedic surgeons. It may be that the condition of the heel due to trauma, commonly referred to by the layman as a "stone bruise", is somewhat similar.

Many adjectives have appeared in the literature, describing fractures in soldiers that are insidious in onset, as "march", "insufficiency", "exhaustion", "fatigue", "insidious", "creeping", *et cetera*. The British seem to prefer the designation "fatigue fractures", while most American authors use the phrase "march fractures". It seems that the designation "insufficiency fractures" is the most appropriate for this syndrome of the calcaneus.

The fractures are considered unusual, in that:

1. They are of common occurrence in trainees;
2. The diagnosis can be proved, by roentgenogram, only late in the course of the condition, and then only if serial roentgenograms are taken (Those taken in the first few weeks are always negative);
3. They occur only after repeated minimal traumata to the heels;
4. In no single case in this series could a history of specific trauma be elicited from the soldier, even after careful questioning (The patients were not seen usually until some time after the onset of symptoms);
5. The fracture, as visualized roentgenographically, appears to be present only in the cancellous portion of the bone; the cortex usually remains intact, although there was an exception in one patient (Case 52);
6. After careful study of the problem, and after observation of the soldier in the training program, it has been determined that there is no single trauma received by soldiers which will produce the fractures; rather, it is a repeated and rhythmic occurrence of minimal or subthreshold traumata, in all cases.

These fractures, characterized by insidious onset following extensive, repeated, minimal traumata to the heels, as a result of walking, marching, jumping over barriers on obstacle courses, jumping ditches on cross-country runs, and other exercises incident to the training of recruits, differ from march fractures of the metatarsals in that the factor of jumping is present, bringing greater and differently applied traumata to bear on the heels. Many patients stated that they began to have pain in their heels following a type of training known as cross-country runs. This consists of a two-mile course, which is negotiated by running 100 yards, walking 100 yards, running 200, walking 100, running 300 and walking 100, then back to running 100, and so on until the course is completed. The history includes gradually increasing pain in one or both heels, so that, in a week or two, patients appear on sick call for relief.

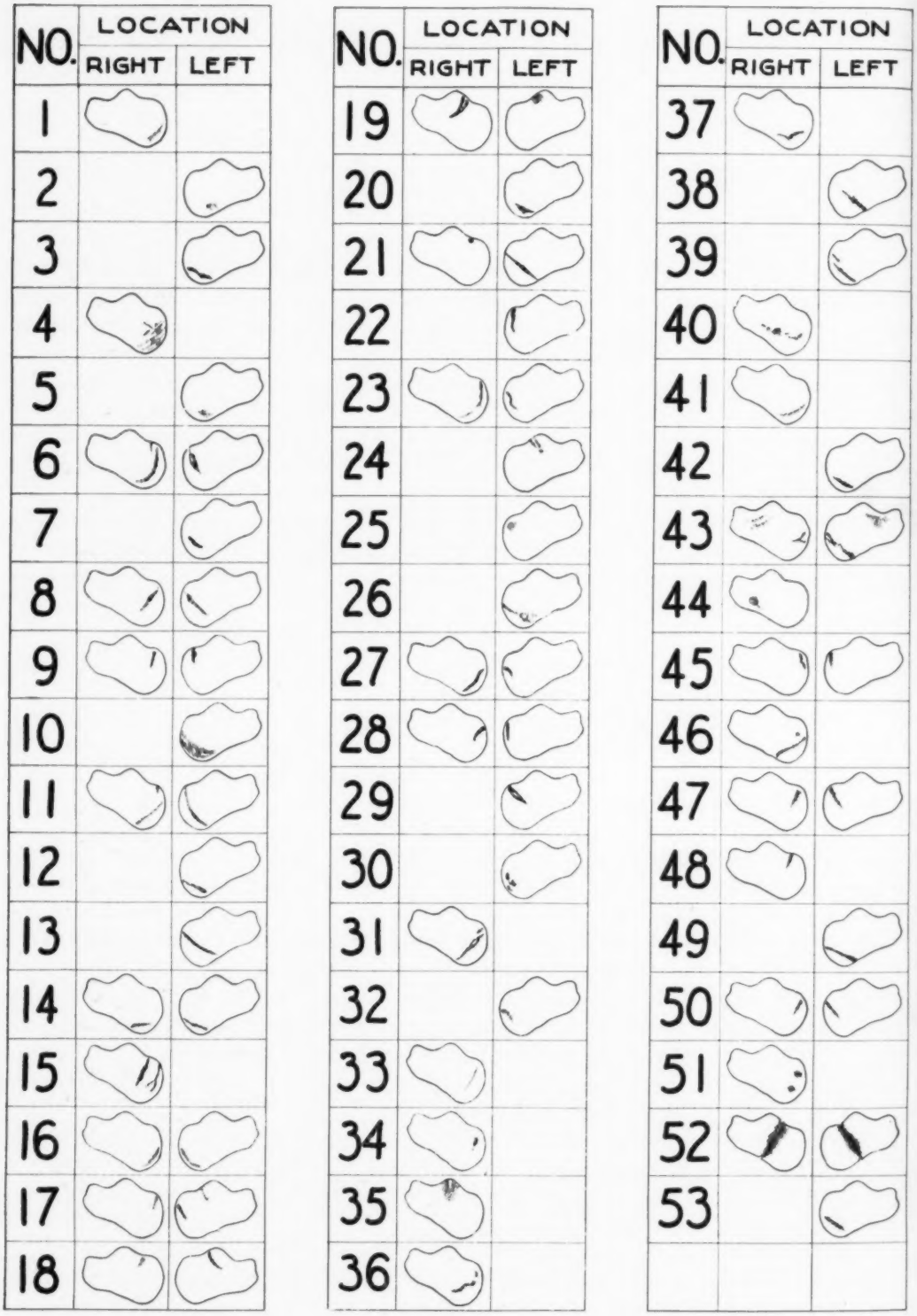

FIG. 1

A schematic drawing showing the location of the callus in the calcaneus in the first fifty-three cases. Pictures were drawn from roentgenograms taken during the healing stage.

FIG. 2-A

Case 31. Posterior view eighteen days after onset of symptoms. Note the diffuse swelling, on the right foot, over the lateral and medial surfaces of the calcaneus, extending up to the malleoli; the left foot is considered normal. This swelling completely subsided after eight days of rest in the Hospital. Patient stated that the swelling was not as bad at the time the photograph was taken as it had been upon other occasions prior to admission. The roentgenogram taken three weeks after admission showed a healing line of calcified callus in the calcaneus (See Figure 1, Case 31).

FIG. 2-B

Anterior view. Note the fullness under the medial malleolus on the right foot.

Examination reveals a diffuse moderate swelling of the soft tissues over the medial and lateral surfaces of the calcaneus, which usually fades out anteriorly over the mid-tarsal region of the foot, and extends superiorly, frequently obliterating the bony landmarks of the malleoli (Figs. 2-A and 2-B). This swelling rapidly disappears after four to ten days of rest in bed, and recurs promptly if the patient is then allowed to walk about the hospital, or is returned to duty. The swelling is not the result of hemorrhage, and does not have the characteristics of a contusion. It would seem to be caused by an increase in extracellular and intracellular fluids, poured out in response to autonomic stimuli arising within the bone. Occasionally, this swelling can be pitted by thumb pressure.

There is moderate pain on walking, usually sufficient to cause a perceptible limp; patients are free from pain as soon as they are off their feet. Tenderness is present on

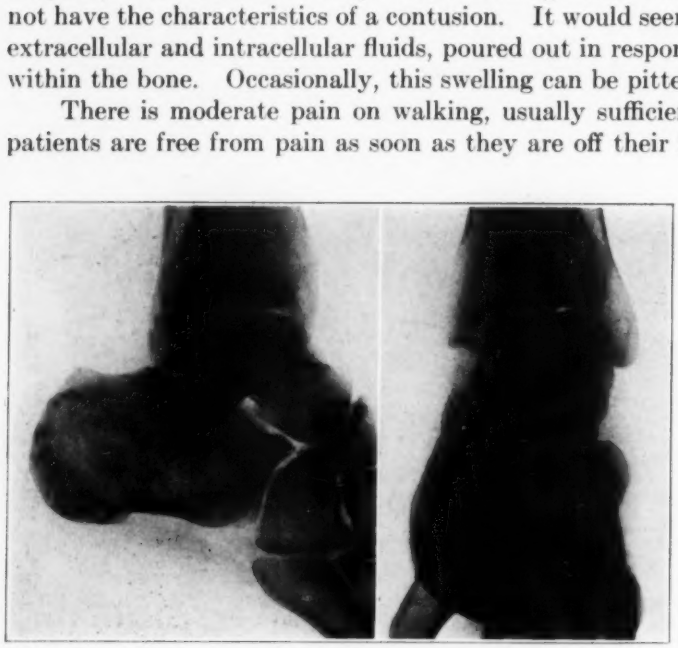

FIG. 3-A

Fig. 3-A: Case 15. Lateral and posterior roentgenograms are entirely negative.

Fig. 3-B: Nineteen days later, a calcified band of callus can be seen extending inferiorly and anteriorly through the posterior half of the body of the calcaneus.

Fig. 3-C: Fifty-six days after the first roentgenogram, and thirty-seven days after the second, a second band of callus can be seen extending anteriorly and inferiorly behind the first band. At this stage, the patient was free from symptoms. He returned to duty, and completed his training cycle without further difficulty.

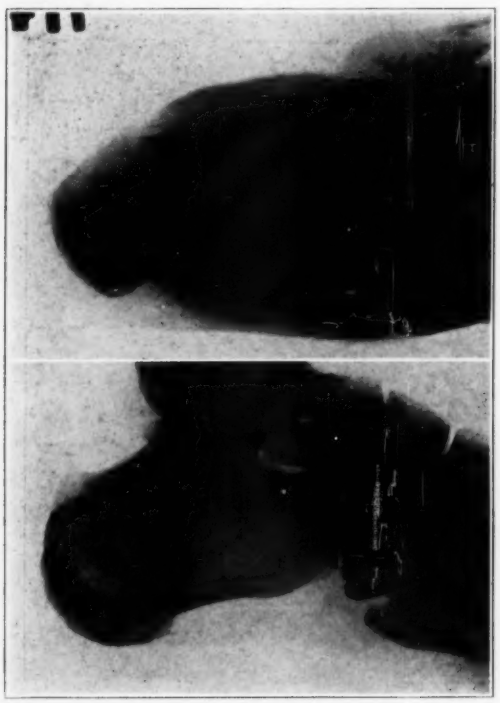

FIG. 3-B

FIG. 3-C

compression of the calcaneus between the thumb and the fingers; this remains for several weeks, even though no swelling is present. There is definite pain elicited on ballottement of the inferior or posterior surfaces of the heel. Stretching of the heel cord by dorsiflexing the foot rarely causes any discomfort, and patients can walk on their toes with less pain than when walking normally. There is occasionally present an associated tendosynovitis of the Achilles tendon or of the tibialis anterior tendon, or of both, the symptoms of which may mask those arising from the fracture of the calcaneus.

During the first four to five weeks after onset, in the cases of this series, repeated roentgenograms of the calcaneus from all angles were negative for any evidence of fracture (Figs. 3-A and 4-A). During this period and before the condition was recognized, many patients were returned to duty after the swelling had subsided. There was a prompt and definite recurrence of symptoms with the same or greater severity, necessitating readmission to the Hospital. Repeated roentgenograms, after five to eight weeks, showed an irregular sclerotic line of callus, frequently five millimeters wide, in the posterior half of the calcaneus, extending incompletely through the bone, and transverse to the long axis, indicating a healing fracture of this bone (Figs. 3-B and 4-B).

The pathological changes in these cases, as determined by follow-up roentgenographic examination, would seem to be as follows:

The condition begins as an incomplete fracture of a few of the bony trabeculations within the calcaneus. Due to the anatomical structure of the calcaneus—cancellous bone throughout, encased by a thin layer of cortical bone—the fracture line extends irregularly in all planes. There is no displacement, and the fracture extends such a relatively short distance in any one plane that roentgenograms coming from one plane can pass through the fracture line only in that plane, and the dehiscence is not revealed. As the trauma is

FIG. 4-A

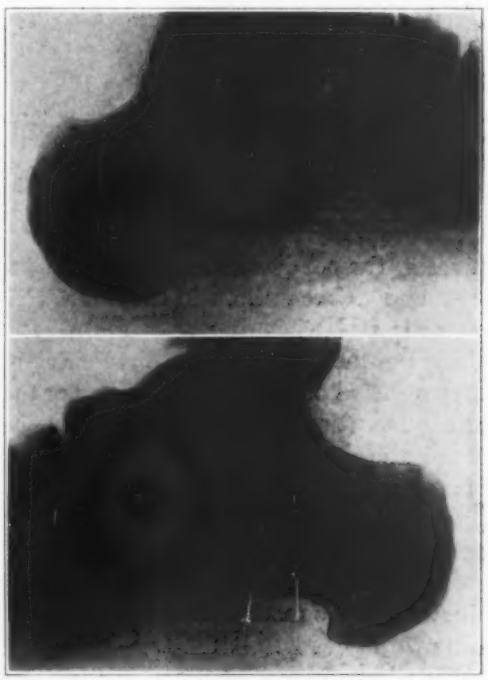

FIG. 4-B

Fig. 4-A: Case 6. Lateral view of both calcanei. At this stage, the patient had marked symptoms and swelling of both heels. The roentgenograms are entirely negative.

Fig. 4-B: Sixteen days later, a healing band of callus can be seen in both heels, and is symmetrically located. The patient returned to duty twelve days after this roentgenogram was taken, and remained free from symptoms.

FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 52. The right heel at the time of the first roentgenogram. Note that the fracture is complete.

Fig. 5-B: The left heel at the time of the first roentgenogram. There is a complete fracture line extending through the body of the calcaneus.

continued, the fracture line may be extended; and, if it extends through the cortex, it may be seen early, as in Case 52 (Figs. 5-A and 5-B). There is also present swelling of the overlying tissue, and oedema, as seen in all fractures, but without ecchymosis, since the bleeding from the fracture site does not get through the usually intact cortex and periosteum.

In all but two cases in this series (Cases 43 and 44, Fig. 1), the fracture was located in the posterior half of the calcaneus. In Case 43, in addition to the fracture in the anterior half, there was a fracture in the posterior half, which appeared at a later date. In nearly all cases, the condensation line of callus appeared to run transverse to the heavy lines of stress and trabeculations in the bone. The fracture in eighteen cases (33 per cent.) was bilateral; and when it was bilateral, it was usually symmetrically located. The left calcaneus was fractured in thirty-eight patients, and the right in thirty-three patients. After a period of an additional three or more months, roentgenograms showed a fading of the condensation of callus. Trabeculations could be seen traversing the fracture site and these trabeculation lines had an increased thickness at this site. A few of the patients in this series had multiple fractures in the same calcaneus, the healing calcification of which appeared at different times (Cases 15 and 43). The stages of healing in Case 15 are shown in Figures 3-A, 3-B, and 3-C.

Blood-chemistry studies, including calcium, phosphorus, and phosphatase determinations, were made on ten patients, and, in all cases, were found to be within normal limits.

We have had at Camp Wheeler seventy-one proved cases of this condition in fifty-three patients. Fifty-one of these patients originally had negative roentgenograms, and the areas of callus appeared on subsequent roentgenograms. Most of the patients appeared from July 1, 1943, to February 1, 1944. The true diagnosis in many of the fifty-three patients was not made at first, as we had not become aware of the condition, and the many erroneous diagnoses included: synovitis of the ankle joint, synovitis of the subtalar

joint, strain of the subtalar joint, contusion of the heel, oedema of undetermined origin, *et cetera*.

There were twenty-seven additional patients who had the early clinical findings of the positive cases; but, either because of change of Station or discharge from the Army for other causes, follow-up roentgenograms were not made, and the diagnoses were not proved; these cases are not included in this series.

The condition was most frequently seen in the older trainees—the average age being thirty—with inadequate muscle development, particularly of the feet and legs, and frequently with inadequate personalities, many of whom seemed to adjust poorly to the Army training program.

The diagnosis was made early only on the history, signs, symptoms, and course of the condition. After about six to ten weeks, it was confirmed by the appearance of the streak of calcified callus, seen in the roentgenograms of the calcaneus. Recognition of the condition is important, in order to avoid punishing these men by returning them to duty before the fracture has healed.

Primary treatment for these patients included rest, avoidance of weight-bearing on heels, and physical therapy. A little later, felt-heel inserts or rubber-heel elevations, or both, were used. After a period of eight to ten weeks, the men were able to return to full military duty. No recurrences have been seen in patients treated in this manner. In Case 52 (Figs. 5-A and 5-B), in which the fractures were complete bilaterally, molded, non-padded, plaster-of-Paris casts were applied for eight weeks; after an additional four weeks, the patient returned to full duty. The subtalar arthralgia and pain on walking, seen so frequently in crush fractures of the calcaneus, were not present in any of these patients.

SUMMARY

1. A large series of fractures of the calcaneus of a distinct type has been presented.

2. The fractures are of an insufficiency type, found for the most part in older soldiers who are inadequate physically and structurally, and who frequently have inadequate personalities.

3. The fractures are not demonstrated by roentgenograms until the healing stage.

4. The fractures are of importance only for the temporary disability that they produce.

5. Recognition is important, to avoid the physical punishment to the individual of continuing full duty.

6. Treatment is simple, and consists of avoidance of weight-bearing until the fracture has healed.

NOTE: Since this paper was written, forty-nine additional patients with these fractures have been seen, and in eighteen of these cases, the fractures were bilateral and symmetrical.

REFERENCES

BERKMAN, E.: Etiological Possibilities of March Fractures. J. Bone and Joint Surg., XXV, 206, Jan. 1943.

BUSH, L. F.: March Foot (March Fracture). Its Early Diagnosis and Treatment. Bull. U. S. Army Med. Dept., No. 68, 126, 1943.

CAMP, J. D., AND MCCULLOUGH, J. A. L.: Pseudofractures in Diseases Affecting the Skeletal System. Radiology, XXXVI, 651, 1941.

CHILDRESS, H. M.: March Fractures of the Lower Extremity. Report of a Case of March Fracture of a Cuneiform Bone. War Med., IV, 152, 1943.

HULLINGER, C. W., AND TYLER, W. L.: March Fractures. Report of 313 Cases. Bull. U. S. Army Med. Dept., No. 80, 72, Sept. 1944.

KEITH, SIR ARTHUR: The History of the Human Foot and Its Bearing on Orthopaedic Practice. J. Bone and Joint Surg., XI, 10, Jan. 1929.

SWEET, H. E., AND KISNER, W. H.: March Fractures. J. Bone and Joint Surg., XXV, 188, Jan. 1943.

URIST, M. R., AND JOHNSON, R. W., JR.: Calcification and Ossification. IV. The Healing of Fractures in Man under Clinical Conditions. J. Bone and Joint Surg., XXV, 375, July 1943.

THE OS PURUM IMPLANT

A Substitute for the Autogenous Implant

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Ollier, in 1867, was the first to use autogenous bone implants. No one has reported a completely satisfactory substitute since. According to Barth, transplanted bone dies and surrounding granulations penetrate the graft. He used sterile, preserved ox bone, freed of organic substance by burning. Harbin and Liber believe that portions of bone transplants remain alive and active, and have suggested a creeping substitution of most of the graft as the explanation of the process which occurs during the "take". Steindler states that necrosis of all cellular elements of the graft is the rule, with replacement by cellular elements from the host. Watson-Jones believes there can be little doubt that an autogenous graft, living at the time of operation, is superior to a boiled, dead graft. King, in discussing autogenous bone grafts, states that the endosteum of the graft is probably the most active source of new cellular growth within implantations.

Consideration of all factors necessary for a successful implantation brought Svante Orell to prepare his "Os Purum" and to report its various uses. Chigot, Danis, and others have used os purum with equal success. De Romana shapes plates and screws of os purum and uses them in fresh fractures. Orell has also used os purum in the unique form of a ball of firm cancellous bone as an intramedullary valve splint, as well as intramedullary strips of cortical os purum for fixation in tubular-bone fractures. He believes that the presence of os purum not only stimulates new-bone formation, but that it stands up under all functional stress and strain as well as autogenous implants do.

Many surgeons object to the use of intramedullary implants for tubular-bone fixation. These objections are generally made on the supposition that such an implant is pounded into the medullary portions, blocking the medullary cavity. Compere and Banks, on the other hand, see no drawbacks to the use of intramedullary-peg fixation. When os purum is used in strip form, the free flow of blood around the implant is not interfered with. Leriche and Policard state that implantation of a transplant in the medullary cavity is not a good fixation procedure, because the portion pushed into the bone canal is rapidly rehabilitated and resorbed, before the portion at the fracture site can be incorporated into the callus. This process sets up a barrier to the endosteal cells, and can lead to poor union. They add further, however, that an implant surrounded by cancellous living bone—such as the neck of the humerus or femur—is rapidly resorbed, and substitution takes place which usually produces excellent union. (In the author's cases such proved to be the situation,—for example, see Case 1, Table III.) Leriche and Policard further note that extra-osseous transplants are resorbed slowly. Those of os purum behave in the same way as autogenous implants in such positions.

It is generally accepted that embryonic connective tissue invades only the haversian canals of the implant. Only these cavities have a caliber large enough to permit the entrance of new vascularized connective tissue. The cavities of the bone cells themselves remain empty forever; even bacteria cannot enter them. Tissue debris and bone dust can permanently block some of the haversian canals. Urist and Johnson have exhaustively demonstrated the presence of this debris and bone dust, as well as larger bone fragments, at the site of fracture. It is, therefore, obvious that the bone lattice work of either an autogenous implant or one of os purum must have spaces sufficiently large to permit embryonic connective tissue to enter. Thus, cancellous bone is, of course, superior. Brooks established a two-stage method for this purpose. He cut the graft from its bed, but allowed it to remain in its donor bed for two weeks. He then lifted the implant and

transferred it to the region desired. His implants took more rapidly and with greater surety than when a one-stage method was used.

Chutro noted that a bone graft unites better, if the donor area has been affected by some trophic or nutritional disturbance; in this the reasoning is the same. Others, in place of a single graft, use match sticks, or grafts that have been cut into small bits, all for the same purpose.

Lickteig prepared swine bone with the aid of human serum. This produced implants that were also quite satisfactory. Hard, compact bone, which, of course, contains few haversian canals, is less favorable for rehabilitation. Such bone unites by its surface only, repopulated by living cells from the host. Such transplants are tolerated a long time by the tissues, and are eventually incorporated into the host. (The entire femur of a cadaver and the fibula of a monkey have been used to replace congenitally absent bones.) For months or even years there may appear no change in such transplants. Eventually, however, there comes a time when roentgenographically the shadow begins to change. There can be either separation or spontaneous fracture. Rarefaction has slowly done its work.

Os purum implants unite more slowly than autogenous transplants, which are living when taken from the host. Boiling changes the collagen of an autogenous implant to a glue, which is practically insoluble in tissue fluids and acts as a definite barrier to resorption of such an implant. Leriche and Policard believe that, in any event, at the end of a certain time the condition of grafts is identical, whether they are composed of dead bone, living bone, or the bone of another animal. They refer to the often-quoted experiment of Hey Groves.

Hughes recently reported experimental work, comparing autogenous pegs, boiled beef-bone pegs, cow horn, and ivory pegs as to rate of absorption or substitution and callus stimulation. In the light of this study it might be assumed that os purum pegs would fit in between autogenous and boiled beef bone. However, again it has been proved that autogenous implants are superior. It is well known that a transplant of dead bone will fracture on occasion, and will undergo complete repair of the fracture. This suggests an unfolding of its biological life under certain conditions, similar to those influencing an autogenous transplant.

The author's experience with os purum grafts is as follows:

Spine Fusion

A total of twenty-eight patients, varying in age from nine to twenty-nine years, are included in this group (Table I). In almost every instance, a turnbuckle jacket was used for correction or improvement of the scoliosis. The primary curve was then fused through a fenestration, after the method of Hibbs but omitting in some cases the destruction of the articulations. The spinous processes and laminae were exposed to the articular areas. Using offset gouges, as many osteoperiosteal shavings as could be obtained were cut from the spinous processes and laminae. These were laid to form a smooth, flat bed on which the os purum was placed. A single piece of thin cortical bone was used, or sometimes two, three, or even five narrower and shorter pieces were placed so that they overlapped at least one inch. Muscle, periosteal, and fascial structures were then closed in the midline, to hold the os purum snugly and fix it to the bed of autogenous chips. A pressure pad of covered felt was applied, and the patient was placed on his back to limit postoperative bleeding.

Six to ten weeks later, a new plaster jacket was applied, with the patient supine on a frame. This jacket was kept on for eight to ten weeks, then changed for the first ambulatory jacket with shoulder straps. A support or jacket was used after fusion for at least a year, occasionally for eighteen months.

In two of the author's cases, clothespin-shaped implants were used at each end of the

TABLE I

USE OF OS PURUM IN SPINE FUSION

Case	Age	Operation	Indications	Period of Observation	Complications	End Result (Fate of Graft)*
1. J. O.	18	Spine fusion (1) T. 7 to L. 1 (2) T. 12 to L. 5 Secondary curve fused (due to error in judgment)	Scoliosis (due to infantile paralysis)	72 months	Pseudarthrosis at level of first and second lumbar vertebrae. (Closed by autogenous graft from tibia.)	Complete take
2. C. C.	19	Spine fusion (1) L. 1 to S. 2 (2) T. 7 to L. 1	Scoliosis (due to infantile paralysis)	58 months	None	Complete take
3. W. C.	19	Spine fusion (1) T. 5 to T. 9 (2) T. 9 to L. 1	Scoliosis (due to infantile paralysis)	49 months	Wound infection. Sliver sequestra of os purum discharged, 4 months after operation.	Complete take. Wound healed.
4. N. C.	14	Spine fusion (1) T. 7 to T. 12 (2) T. 3 to T. 7	Scoliosis (due to infantile paralysis)	48 months	Graft not tolerated; serous discharge from wound. (Graft removed, fourth month.)	Area fused without graft.
5. K. W.	14	Spine fusion (1) T. 3 to T. 9 (2) T. 9 to L. 1	Scoliosis (due to infantile paralysis)	44 months	None	Complete take
6. A. W.	20	Spine fusion (1) T. 5 to T. 10 (2) T. 10 to L. 1	Scoliosis (idiopathic)	60 months	Lower end of one graft incomplete take. No pseudarthrosis.	Incomplete take
7. P. R.	19	Spine fusion T. 7 to L. 2	Scoliosis (due to infantile paralysis)	37 months	None	Complete take
8. A. D.	18	Spine fusion T. 6 to T. 12	Scoliosis (idiopathic)	35 months	None	Complete take
9. H. C.	17	Spine fusion T. 5 to T. 12	Scoliosis (due to infantile paralysis)	35 months	None	Complete take
10. A. T.	17	Spine fusion (1) C. 7 to T. 7 (2) T. 7 to T. 11 Resection of 4th and 5th ribs (left)	Scoliosis (due to congenital fusion of 2 ribs)	33 months	None	Complete take
11. L. W.	17	Spine fusion (1) C. 7 to T. 5 (2) T. 4 to T. 10	Scoliosis (due to infantile paralysis)	32 months	None	Complete take
12. J. A.	17	Spine fusion T. 6 to T. 12	Familial scoliosis Pituitary dyscrasia	42 months	None	Complete take. Second operation refused.
13. E. L.	20	Spine fusion (1) T. 2 to T. 9 (2) T. 8 to L. 2	Scoliosis (due to infantile paralysis)	28 months	None	Complete take
14. G. H.	17	Spine fusion T. 8 to L. 1	Scoliosis (due to infantile paralysis)	28 months	None	Complete take
15. D. C.	10	Spine fusion T. 5 to T. 7	Von Recklinghausen's disease with marked scoliosis.	26 months	None	Complete take

TABLE I (*Continued*)

Case	Age	Operation	Indications	Period of Observation	Complications	End Result (Fate of Graft)*
16. C. B.	17	Spine fusion (1) C. 6 to T. 4 (2) T. 4 to T. 10	Scoliosis (due to infantile paralysis)	24 months	None	Complete take
17. R. D.	14	Spine fusion T. 2 to T. 7	Scoliosis (due to infantile paralysis)	33 months	None	Complete take
18. B. C.	10	Spine fusion T. 3 to T. 12	Scoliosis (due to infantile paralysis)	18 months	None	Complete take
19. J. F.	14	Spine fusion (1) T. 1 to T. 6 (2) T. 6 to L. 1 (3) L. 1 to S. 2	Scoliosis (due to infantile paralysis)	29 months	None	Entire thoracic and lumbar area fused to sacrum. Complete take
20. M. C.	18	Spine fusion (1) T. 3 to T. 10 (2) T. 10 to L. 3	Scoliosis (due to hemivertebra in thoracic region)	12 months	None	Complete take
21. C. M.	19	Spine fusion (1) L. 2 to S. 3 (2) T. 8 to L. 2	Scoliosis (due to infantile paralysis)	18 months	None	Complete take
22. W. S.	10	Spine fusion T. 9 to L. 2	Scoliosis (due to hemivertebra)	12 months	None	Complete take
23. H. N.	14	Spine fusion (1) T. 3 to T. 9 (2) T. 9 to L. 3	Scoliosis (idiopathic)	14 months	None	Complete take
24. N. G.	17	Spine fusion (1) T. 4 to T. 10 (2) T. 9 to L. 4 (3) T. 8 to T. 10	Scoliosis (idiopathic)	16 months	Incomplete fusion, ninth to tenth thoracic vertebrae	Complete take
25. A. E.	14	Spine fusion T. 4 to T. 12	Scoliosis (idiopathic)	36 months	None	Complete take
26. S. F.	9	Spine fusion T. 2 to T. 9	Scoliosis (congenital anomaly)	36 months	None	Complete take
27. N.	28	Lumbosacral fusion	Spondylolisthesis	60 months	Lower end of graft did not unite; was removed 14 months after implantation.	Incomplete take but successful fusion.
28. V. S.	29	Lumbosacral fusion	Unstable lumbrosacral junction after removal of herniated fifth lumbar intervertebral disc.	14 months	None	Complete take (graft fixed in place with steel wire).

(1) First stage; (2) second stage; (3) third stage.

* In estimating the end results in these cases, the author has taken as his criteria the continuity of the fusion slab, as demonstrated by lateral, oblique roentgenograms, and the absence, clinically, of false motion throughout the fusion area.

fusion area, in an effort to fasten these to spinous processes. In another case (Case 24), the two fusion areas were not overlapped, and a third stage was required to close the gap. An autogenous graft was used, as this was deemed the best means of procuring union in this difficult case.

Os Purum Peg Fixation of Cancellous Bones

In the cases where this method was used (Table II), square or round pegs of os purum were pounded with ease into the cancellous bone. A wooden mallet was employed, al-

TABLE II

USE OF OS PURUM PEG FIXATION IN CANCELLOUS BONES

Case	Age	Operation	Indications	Period of Observation	Complications	End Result (Fate of Graft)
1. F. G.	11	Posterior bone block with triple arthrodesis. After 24 months, ankle fusion to increase stability. Os purum pegs used for tibio-astragalar fixation.	Equinus (due to infantile paralysis) Foot and ankle unstable	48 months	None	Complete take. Bone block corrected equinus. Ankle fusion obtained after 2nd operation.
2. K. W.	15	Arthrodesis of shoulder. Os purum peg through acromion.	Paralysis of upper arm (due to infantile paralysis)	36 months	None	Complete take
3. E. J.	18	Arthrodesis of shoulder. Os purum peg through acromion.	Obstetrical paralysis (whole arm)	36 months	Wound infection. Peg fractured, and outer portion sloughed.	Incomplete take, but arthrodesis excellent.
4. A. R.	9	Panarthrodesis, with os purum pegs transfixing malleoli and astragalus	Flail-foot (due to infantile paralysis)	17 months	None	Complete take. Solid fusion.
5. X.	51	Os purum pegging of body of fifth lumbar vertebra to sacrum; intra-abdominal approach after Mercer (Case of Dr. M. K. Lindsay).	Spondylolisthesis	36 months	Stormy course, but peg held	Complete take. Fusion obtained.
6. N. N.	17	Transfixion of fragments with os purum peg graft	Non-union of fractured carpal navicular	48 months	Graft sloughed out (imobilization inadequate)	Failure of union
7. P.	34	Transfixion of fragments with os purum peg graft	Non-union of fractured carpal navicular	54 months	None	Complete take
8. D.	41	Intracancellous peg, fixing head of fractured humerus to shaft	Fracture-dislocation of head and neck of humerus	17 months	None	Complete take
9. M. E.	39	Intracancellous-graft fixation in arthrodesis of tarsals (secondary operation)	Fibrous union following triple arthrodesis of astragalus	13 months	None	Complete take

though a wooden adaptor could be used, in order to avoid crushing the os purum. A hole can be drilled beforehand, but this is unnecessary if the peg is sharpened at the penetrating end.

These pegs are somewhat brittle, and the parts must be handled gently after pegging. Union, however, is quite firm.

In such situations Orell would employ his os purum in the form of slot grafts.

Posterior Bone Block for Foot-Drop (Old Infantile Paralysis)

A modified Gill procedure was combined with the "triple arthrodesis" stabilization in ten cases. These have been followed over a period of thirty-six to forty-eight months, with an average follow-up of forty-two and one-half months. The result was excellent in nine cases, an adequate bone block having been secured, which corrected the foot-drop satisfactorily. There was one failure, due to postoperative fracture of the bone implant. The bone-block operation proved ill-advised in one instance (Case 1, Table II), since it was necessary to fuse the ankle later, because of instability. In three of the ten cases in this series a serous discharge developed, and continued until the removal of excess bone from the block, nine, ten, and thirteen months, respectively, after operation, following which the wounds healed promptly. In none of these three cases was the efficacy of the block affected by this complication.

TABLE III

USE OF OS PURUM AS INTRAMEDULLARY GRAFTS IN CORRECTIVE OSTEOTOMIES

Case	Age	Operation	Indications	Period of Observation	Complications	End Result (Fate of Graft)
1. M. L.	52	Corrective osteotomy of tibia. Intramedullary graft	Malunion of fractured tibia and fibula	60 months	Pin-point, draining sinus, five months after operation: culture sterile. Thirty months later, small sequestrum at wound was discharged, with prompt healing	Complete take. Bony union obtained.
2. P. M.	28	Shortening of radius and ulna by resection of one inch of each. Intramedullary peg for fixation and approximation of both bones	Marked posttraumatic contracture of flexors of fingers and wrist	12 months	None	Complete take. Union of bone obtained.
3. P. B.	14	Corrective osteotomy (torsion). Intramedullary graft of radius and ulna	Marked pronation deformity following obstetrical paralysis	12 months	None	Complete take. Union of bone and maintenance of correction.
4. D. K.	48	Wedge osteotomy of radius and implant graft; osteotomy of ulna and intramedullary graft	Deformity of lower end of radius and ulna following fracture	58 months	None	Complete take. Union of bone and maintenance of correction.

TABLE IV

USE OF OS PURUM IN SHELF OPERATION FOR CONGENITAL DISLOCATION OF THE HIP

Case	Age	Operation	Indications	Period of Observation	Complications	End Result
1. I. T.	20	Shelf, for stabilization	Congenital dislocation of hip, old, irreducible (unilateral)	48 months	None	Satisfactory. Shelf persists
2. H. B.	13	Shelf, for stabilization	Congenital dislocation of hip	60 months	None	Satisfactory. Shelf persists
3. J. M.	17	Shelf, for stabilization	Congenital dislocation of hip	36 months	None	Satisfactory. Shelf persists
4. L. A.	3	Bilateral stabilization by shelf of os purum after open reduction	Resistant bilateral dislocation of hip	72 months	None	Fair. Both hips stable; range of motion, 50 per cent. (Reduction maintained, but shelves partially absorbed. Both capital epiphyses were flattened, three years after operation.)
5. S. V.	5	Bilateral stabilization by shelf of os purum after open reduction	Bilateral congenital dislocation of hip; irreducible by closed method	72 months	None	Poor: both hips "frozen" ("Fibrosis" of both hips)

Osteotomy and Graft Fixation

There are eight cases in this group:

Four were of the wedge type to correct deformity (tibia, femur, and two radii). In these, the os purum graft was of the cancellous type. Union of bone occurred in all, in the corrected position, and the results were excellent. There were no complications. These cases were followed from fourteen to forty-six months, with an average follow-up of two and four-tenths years.

Four were corrective osteotomies with intramedullary grafts The results are shown in Table III.

Shelf Operation for Congenital Dislocation of the Hip

A total of seven hips are included in this group (Table IV), three unilateral dislocations in young adults and two bilateral dislocations in children. In each instance stabilization by a shelf of os purum was attempted, with or without reduction of the dislocation. The technique employed in the creation of the shelf was as follows: An osteoperiosteal bone flap was laid down from the side of the ilium; this was braced by a piece or cortical os purum, and held in place by an os purum bone peg driven into the ilium. The results in these five cases were as satisfactory as had been those in which autogenous blocks had been used by the author.

Obliteration of Cranial Defect

In two cases, large cranial defects following neurosurgery were successfully treated by the application of os purum grafts. In both, closure was complete without complication. The follow-up period was twenty-four and twenty-six months, respectively.

SUMMARY OF COMPLICATIONS

Removal of Graft

After nine of the eighty operative procedures reported, the os purum implant, whether it was a wide and long slab of bone (such as is used in spine fusions) or a bone peg used in the fixation of a carpal navicular, was removed either *in toto* or in part.

In one of these cases (Case 4, Table I), following a spine-fusion operation, one patient apparently did not tolerate the implant, as manifested by a serous discharge for four months. It was then thought best to lift the implant from its bed. The area, however, went on to an unusually firm, solid fusion. The serous discharge was cultured and found sterile. The os purum may have produced a foreign-body reaction, due to inadequate immobilization, although the same type of fenestrated jacket was used in all cases.

In another instance (Case 27, Table I), the lower half inch of implant failed to unite to the sacrum in a lumbosacral fusion and produced a slight snapping sensation on flexion of the spine. The patient insisted upon having something done for this. A small incision was made over the lower portion of the implant, and approximately one inch of unattached graft was cut away with bone forceps. The fusion area was solid, and an excellent result was obtained.

A spine-fusion operative wound became infected (Case 3, Table I), and several splinters of the os purum implant sloughed out as sequestra, four months after operation. The wound then healed and fusion followed.

In one of these nine cases (Case 3, Table II), a bone peg fractured in a scapulohumeral fusion, following infection. The peg was removed and fusion followed.

Bone blocks, implanted within the astragalus in three cases to overcome foot-drop in conjunction with a triple arthrodesis of the foot, gave rise to a slight serous discharge after several weeks. Ultimately a small portion of the os purum, which was acting as a sequestrum, was removed, and the wounds healed.

An intramedullary splint of cortical bone caused a serous discharge from a pin-point wound in the center of a scar (Case 1, Table III). At the end of two and one-half years a sequestrum, approximately one-half an inch in length and one-quarter of an inch in width, was discharged. This constituted that portion of the os purum intramedullary splint which was located at the site of the osteotomy. The portions of os purum, which were embedded within the medullary canals, united and finally disappeared. Unusually hard bony union resulted. Prolonged fixation might have prevented this complication.

A peg, used to fix an old, ununited fracture of a carpal navicular (Case 6, Table II), was extruded spontaneously at the end of twelve weeks, because of insufficient immobilization of the wrist. Continuation of the state of non-union resulted.

Absorption of Graft

In two cases of bilateral congenital dislocation of the hip (Cases 4 and 5, Table IV), irreducible by the closed method, all four reconstructed shelves partially absorbed and the hips became stiff. Analysis proved that these hips were not sufficiently reduced at the time of open operation, and that the operative procedure set up a reaction, so that marked fibrosis developed, with inflexible scar formation. Two of the shelves were re-examined six years later, at the time of a reconstruction procedure (vitallium cup arthroplasty), and were found to be excellent in every way (Case 5, Table IV).

CONCLUSIONS

Eighty operative procedures in sixty-one patients are reported. Sixteen (in fourteen patients) were followed by complications, due directly to os purum in six cases. These six (10 per cent.) included two spine fusions, three posterior bone blocks, and one intra-

medullary splint. All complications totaled 20 per cent., with none constituting a major factor in the end results. The rate of fusion appeared to be slightly slower than in control cases using autogenous implants. The amount of fused bone in which os purum was used was somewhat less, as to size and thickness, than in the autogenous controls. In all but six instances, the os purum seemed to be tolerated practically as well as autogenous bone, and continued to serve its purpose even in the presence of a frank wound infection. As a result of this experience with os purum implants, the following conditions became quite clear to the author:

1. All osteogenic sources about the recipient bed must be carefully preserved.
2. Complete fixation of the parts must follow implantation with os purum.
3. Complete asepsis with the Lane technique is preferred. (In many of the author's cases, sulfanilamide powder was sprinkled into the wound before it was closed, without any appreciable slowing in the rate of acceptance.)
4. Intramedullary fixation can be used in selected cases without complicating the result appreciably.
5. The implant should remain in its bed for sixteen weeks, even if there are signs of intolerance or of foreign-body reaction. By that time it has served its purpose and can be removed.
6. The implant should be shaped to the desired size as carefully as possible. An excess amount of os purum appears to be a long time in absorbing, and may produce a slight serous discharge for several months at the site of the wound. This occurred, however, in a very limited number of cases. Removal of the implant, or of the excess of the implant, will not interfere with bone formation, and the wound will close promptly.
7. Os purum implants, unless under physiological stress and strain and surrounded by osteogenic tissues, will be resorbed and disappear.

The author believes that the use of os purum has its place and constitutes a satisfactory material for the orthopaedic surgeon. For the duration of the War, however, it appears that os purum cannot be obtained from Sweden. The supply in this country is almost exhausted. Perhaps some biochemical manufacturer may see fit to produce os purum in this country, if this can be done under trade agreements.

Leriche and Policard pose three propositions to be fulfilled for the future of bone surgery: (1) Can one influence the formation of bone? (2) Can one influence bone resorption? (3) Can one model new ossifications? The use of Orell's especially prepared bone introduces a substance which promises to go far toward answering these three interesting questions.

REFERENCES

Barth, Arthur: Ueber histologische Befunde nach Knochenimplantationen. Verhandl. d. Deutschen Gesellsch. f. Chir., 22 Kongress, 1893.

Campbell, W. C.: Operative Orthopedics. St. Louis, The C. V. Mosby Co., 1939.

Chigot, P. L.: L'enchevillement central des fractures diaphysaires. Paris, Masson et Cie, 1937.

Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment. Chicago, The Year Book Publishers, Inc., 1943.

Danis, Robert: Technique de l'osteo-synthèse. Étude de quelques procédés. Paris, Masson et Cie, 1932.

Groves, E. W. Hey: Methods and Results of Transplantation of Bone in the Repair of Defects Caused by Injury or Disease. British J. Surg., V, 185, 1917.

Harbin, Maxwell, and Liber, K. E.: The Behavior of Transplanted Bone. A Clinical Consideration. Surg. Gynec. Obstet., LIX, 149, 1934.

Hughes, C. W.: Rate of Absorption and Callus Stimulating Properties of Cow Horn, Ivory, Beef Bone and Autogenous Bone. Surg. Gynec. Obstet., LXXVI, 665, 1943.

King, Thomas: Matti's Spongiosa Bone Transplant for Ununited Fractures. Med. J. Australia, I, 526, 1938.

Leriche, R., and Policard, A.: The Normal and Pathological Physiology of Bone: Its Problems. (Translated by Sherwood Moore and J. A. Key.) St. Louis, The C. V. Mosby Co., 1928.

Lickteig, E.: La reconstitution de la machoire inférieure par les différentes autogreffes et hétérogreffes osseuses. L'Odontologie, LIX, 379, 1921.

OLLIER, L.: Traité expérimental et clinique de la régénération des os et de la production artificielle du tissu osseux. II. Paris, Victor Masson et Fils, 1867.

ORELL, SVANTE: "Osteoplastic Cuneiform Osteotomy" in the Treatment of Ankylosis. Report of Two Cases. J. Bone and Joint Surg., XIV, 643, July 1932.

Interposition of Os Purum in Osteosynthesis after Osteotomy, Resections of Bones and Joints (Interposition-Osteosynthesis). Surg. Gynec. Obstet., LIX, 638, 1934.

Studien über Knochenimplantation und Knochenneubildung, Implantation von "os purum" sowie Transplantation von "os novum". Acta Chir. Scandinavica, LXXIV, Supplementum XXXI, 1934.

Implantation of Os Purum in Tuberculous Osteitis. Nordisk Med. Tidskr., XII, 1346, 1936.

Knochentransplantation. Lennander-Vorlesung, Svenska läk.-sällsk. Handl., LXII, 107, 1936.

La transplantation osseuse. J. de Chir., XLIX, 857, 1936.

Surgical Bone Grafting with "Os Purum", "Os Novum", and "Boiled Bone". J. Bone and Joint Surg., XIX, 873, Oct. 1937.

The Use of Os Purum in Bone Implantations. With Special Reference to Its Use in Tuberculous Bone and Joint Lesions. Surg. Gynec. Obstet., LXVI, 23, 1938.

The Surgical Treatment of Recurrent Dislocation of the Shoulder Joint. Surg. Gynec. Obstet., LXX, 945, 1940.

Über chirurgische Knochentransplantation. Zentralbl. f. Chir., LXVIII, 1398, 1941.

DE ROMANA, J.: El "os purum" como elemento biológico de prótesis interna. Día méd. (Ed. espec.), No. 2, 19, 1939.

STEINDLER, ARTHUR: Orthopedic Operations. Indications. Technique and End Results. Springfield, Illinois, Charles C. Thomas, 1940.

URIST, M. R., AND JOHNSON, R. W., JR.: Calcification and Ossification. IV. The Healing of Fractures in Man under Clinical Conditions. J. Bone and Joint Surg., XXV, 375, Apr. 1943.

WATSON-JONES, R.: Fractures and Other Bone and Joint Injuries. Baltimore, The Williams and Wilkins Co. 1940.

A SIMPLE ROENTGENOGRAPHIC METHOD FOR THE MEASUREMENT OF BONE LENGTH

A MODIFICATION OF MILLWEE'S METHOD OF SLIT SCANOGRAPHY

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Exact methods for the measurement of bone length are necessary in studying the growth of the long bones in children, and are useful in many other problems in orthopaedic surgery. This paper presents a simple modification of Millwee's slit scanography, which is highly accurate and requires no complicated apparatus. Any smooth-rolling tube stand, mounting a tube of 100-milliampere to 200-milliampere capacity, may be quickly converted to this purpose.

In 1937, Millwee[1] introduced slit scanography, a method of roentgenography designed to abolish distortion and overlapping of shadows in one plane. A continuous exposure was made by moving a narrow and transverse beam of radiation along the long axis of the part

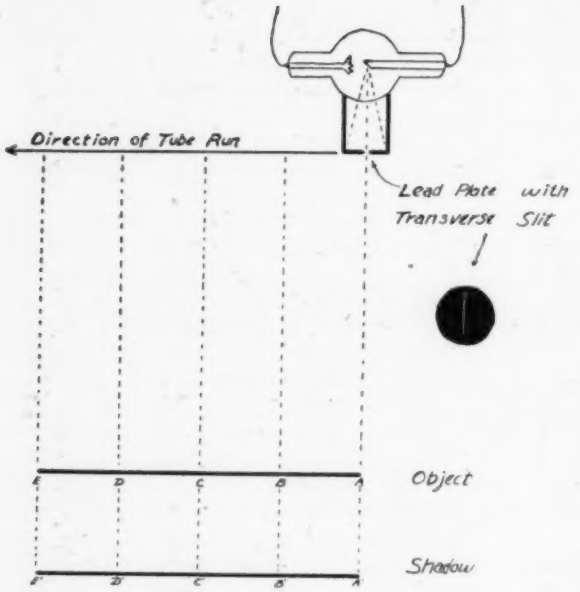

FIG. 1

Drawing illustrating the principle upon which this method is based.

visualized. His equipment consisted of a mounted tube moved along a track by a worm gear and electric motor. A narrow transverse beam of rays was produced by an adjustable transverse slit. To safeguard further against scatter, a slotted lead apron was moved over the plate and under the patient, who was supported on a tunnel. This apron was connected to the tube stand by a side arm.

The effect produced was as though the tube were centered exactly over each point in the long axis of a part (Fig. 1). All rays struck the object and the plate perpendicular to and transverse to the direction of the tube run. Therefore, if an object was placed horizontal to and parallel with the run of the tube, there was no magnification in this plane, regardless of the distance of the tube from the part or the height of the part from the plate. The transverse dimensions of the part, however, were distorted as in ordinary films, but this distortion was small, since the angle subtended by the narrow width of the bone was small.

Millwee demonstrated that this method abolished the overlapping seen in routine roentgenograms of the spine. He presented roentgenograms in which the usual superimposition of the vertebral bodies was completely eliminated. The inherent difficulty in this method was obviously due to the long exposure time required. Millwee had only tubes of fifty-milliampere capacity. To avoid this difficulty, he considered using a series of three tubes instead of one.

Since the author had 200-milliampere tubes available, he felt that the long exposure time was not an insurmountable factor. After some experience, a simple modification of this apparatus was devised. The tunnel and side-arm apron guard were found to be unnecessary, and only a simple slotted lead plate was used to produce the transverse beam of radiation. This was made from a square piece of lead which fitted the usual cone mounting. A transverse slit, two millimeters in width, was cut in the lead piece. The tube was moved by a rope and pulley attached to a weight. When the weight was released, the tube moved at a slow, constantly accelerating speed. The most satisfactory rate of motion was about thirty-six inches per ten seconds. If moved faster, transverse lines appeared in the roentgenograms which were interpreted as due to alternating frequency of the electric current. The accelerating speed of the tube was of advantage in examining the extremities, since the thickness of the leg diminishes from the hip downward. For this reason, each exposure is begun at the upper end of the bone.

The determination of the exposure factor has not been difficult. Since the beam of radiation moves along the bone, each portion must receive, during a short interval, the same amount of radiation it would receive in routine roentgenography. As the distance of the tube run and the time are fixed, the proper exposure is determined by variation of the milliamperage and the kilovoltage. In each instance, however, care must be taken lest the latter factors cause overheating of the tube. Fortunately, as pointed out previously, the tube distance plays no part in the accuracy of the measurements obtained. For this

FIG. 2-A

FIG. 2-B

Reproductions of scanograms showing the quality of the films obtained.

reason the tube may be placed very close to the part. Since the power required varies inversely with the square of the tube distance, considerable saving of power may thus be obtained. In the author's experience, the quality of the roentgenograms has been best with the tube distance at about thirty inches.

If available, the planigraph may be easily converted into a scanographic apparatus. The lead plate is inserted as described above. The eccentric tube arm connected with the tube and Bucky diaphragm is removed. Since the tube is moved by a worm-gear motor, the speed may be accurately measured, which makes determination of exposure time very simple.

Roentgenograms of excellent quality were very easily obtained, and the detail was exceptionally good (Fig. 2). In many tests with measured objects suspended as high as ten inches from the plate, exact measurements were reproduced. In no case was the error of distortion over 2 per cent. It is believed by the author that this method is distinctly superior to other methods which have been previously used in studying the growth of extremities. It was, therefore, instituted in the study of the growth of limbs following poliomyelitis, which is being carried out at the New York Orthopaedic Hospital under a grant from The National Foundation for Infantile Paralysis.

Appreciation is expressed for the assistance rendered by Dr. Lawson E. Miller, Radiologist of the New York Orthopaedic Dispensary and Hospital.

1. MILLWEE, R. H.: Slit Scanography. Radiology, XXVIII, 483, 1937.

CONSERVATIVE TREATMENT OF FRACTURE OF THE CLAVICLE

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The purpose of this paper is to present a simple, practical method for the treatment of fractured clavicles. The procedure includes the injection of a local anaesthetic into the fracture site, the reduction of the fracture by manipulation of the fragments and general positioning of the shoulders, and the maintenance of the reduction by immobilization in a light plaster cast. This treatment permits the complete freedom of both arms. It also allows the soldier to wear a uniform over the appliance, and to return to his unit on a temporary limited-service basis.

Treatment of the fractured clavicle has run the gamut from extreme conservatism, with complete bed rest and sandbags, to the method of internal fixation with Kirschner wire, described by Murray. The latter method is not without some disconcerting complications.

Fracture of the clavicle is not an uncommon injury in the Military Service, and makes up a fair percentage of those cases that are treated in station and field hospitals. The condition is simple in itself, but the treatment must be determined in consideration of the problem of the final disposition of the case. The patient obviously must be made ambulatory as soon as possible; but this is not enough, if he cannot care for himself, and needs constant assistance in clothing and feeding himself, and aid in his personal hygiene.

Because of the inconvenience in handling this type of patient, these soldiers are kept in station hospitals about six weeks, until their convalescence is complete; often the patient must be reassigned to a new unit upon his release to duty. The separation of a man from his old organization is bad for morale, and is to be avoided whenever possible.

At the Fort Belvoir Station Hospital all types of conservative treatment have been tried to find the most feasible and foolproof method. Complete bed rest, with sandbag immobilization, has been used in only a few cases and only for temporary purposes. The cases were those in which shock, head injuries, and other severe complications of trauma obviated any further treatment in the early stages. These patients were always placed on a hard fracture-board bed, with or without the sandbag on the affected shoulder. As soon as the patient was able to cooperate and was out of danger, the clavicular cross was applied. In some patients, this treatment worked fairly well; in others, it failed. The common complaints were that it was uncomfortable for the patient in bed, and that it was constantly slipping out of position and needing repeated padding under the shoulder straps and general realignment. Nursing care was greatly increased, and it was difficult to prop and turn the patient as needed. The simple modification of the clavicular cross—that is, the straight board splint applied across the shoulders and maintained by tape—was entirely unsatisfactory for bed and ambulatory cases for similar reasons.

The figure-of-eight dressing, made of padded stockinette, with or without a felt pressure pad over the fracture, proved satisfactory in greenstick or incomplete fractures. It was unsatisfactory in bed patients from the standpoint of comfort and convenience, and did not give the proper support. Often in the ambulatory cases, it produced circulatory and nerve disturbances in the arms and hands, because of constriction under the armpits. Constant readjusting, tightening, padding, and powdering of the axillae were needed to such an extent that the patient was obliged to make almost daily visits to the Hospital for attention. The figure-of-eight bandage became almost intolerable in hot weather, because of chafing; patients primarily treated with the figure-of-eight bandage were considered as hospital cases until completely recovered.

The Sayre tape dressing and the Velpeau bandage as methods of treatment were discarded early. Skin rash from tape often necessitated a change in the type of treatment. It was necessary to immobilize one arm for approximately a month. This procedure handicapped the patient to the extent that he had to be assisted in dressing, and was unable to wear the military uniform. Moreover, immobilization of the fracture was not ideal, and the patients, while carrying on light duties for several weeks, often complained of painful crepitation at the fracture site. These patients were hospital cases for six weeks.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Case 1. Patient with cast applied for fractured clavicle.
Fig. 1-B: Patient wearing military uniform over cast.

FIG. 1-C

FIG. 1-D

Fig. 1-C: Roentgenogram showing comminution of clavicle.
Fig. 1-D: Roentgenogram showing solid bony union after eight weeks; good clinical and cosmetic result.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case 2. Roentgenogram showing fracture of clavicle.
Fig. 2-B: Roentgenogram showing callus formation and solid bony union after six weeks.

Open reduction, and fixation by means of the Kirschner wire, after the method of Murray, was done in one case in which the distal end of the clavicle was comminuted and markedly displaced, with an avulsion of the clavicular attachments of the coracoclavicular ligaments. An identical fracture, involving the distal one inch of the clavicle, with rupture of the coracoclavicular ligaments, but of the greenstick type with angulation, was treated by the cast method. Both fractures healed with good functional results.

Various types of plaster casts were experimented with, until the present form was developed. The earliest type was a padded figure-of-eight. The difficulty encountered was that, if enough plaster was removed from the armpits to allow the arms to hang at the sides, there was not enough left for support of the shoulders. The second modification tried was that in which a bowed wooden splint was placed in front of the chest and anchored at its ends to the plaster covering the shoulders, for the purpose of abducting them. The entire device was out of balance and rocked on the shoulders; it also made it impossible to wear a shirt.

The method of Kini, the use of a plaster axillary crutch anchored to a pelvic plaster band, was found to be too cumbersome for general use.

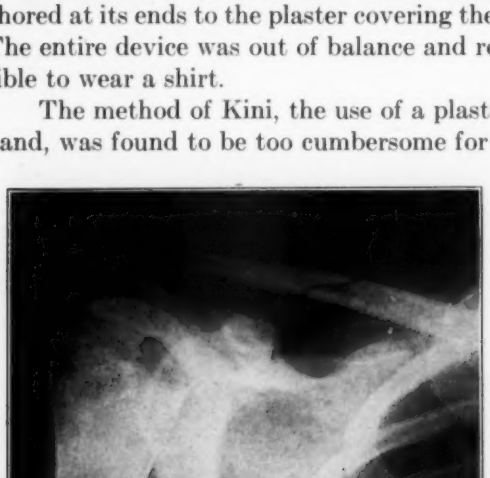

FIG. 3-A

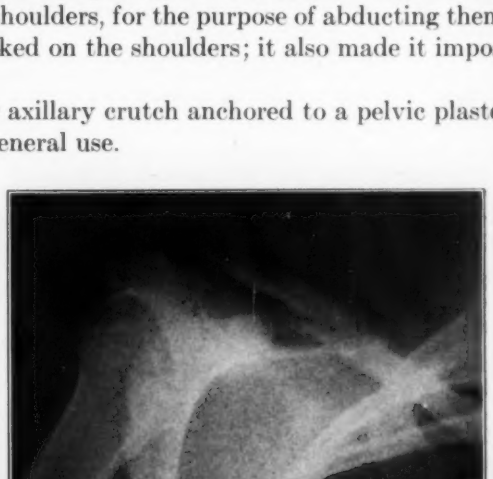

FIG. 3-B

Fig. 3-A: Case 3. Roentgenogram showing fracture of clavicle.
Fig. 3-B: Roentgenogram showing callus formation and solid bony union after six weeks.

FIG. 4-A

FIG. 4-B

Fig. 4-A: Case 4. Roentgenogram showing fracture of clavicle.
Fig. 4-B: Showing bony union and excellent result. The callus is firm and not massive.

The following method has become routine for the treatment of fractured clavicle at the Fort Belvoir Station Hospital. A total of thirty-four fractures of the clavicle have been treated by this method:

Under sterile technique, five to ten cubic centimeters of a 1 or 2 per cent. solution of novocain is injected into the hematoma at the fracture site. The patient is then seated on a stool and the shoulders are drawn back by an assistant, while at the same time the arm on the fractured side is elevated and externally rotated by another assistant. The operator manipulates the fracture until the fragments are in alignment. Then, while the position is maintained by the assistants, a felt pressure pad is firmly taped over the proximal fragment. The purpose of the pressure pad is to make the proximal fragment bear the weight of the cast, thus aiding in maintaining reduction. The cast is then applied as a snugly-fitting jacket, extending down to the lower ribs, closely applied to the root of the neck and well out to both deltoid muscles anteriorly. The plaster is trimmed from under the armpits to allow the limbs to hang normally without embarrassment to the circulation.

When the cast has hardened, the assistants release the pressure on the shoulders; the patient should then experience a feeling of adequate support and no crepitation with respiration. The cast is allowed to remain in place for six weeks, more or less, depending upon the severity of the fracture. If tenderness is still present after removal of the cast, a lightly applied padded figure-of-eight stockinette bandage is used for two more weeks of convalescence. Occasionally the cast becomes loose, and should be reapplied snugly about the fracture.

In the thirty-four patients treated according to this technique, there was no case of non-union, restriction in shoulder motion, or residual pain at the acromioclavicular or sternoclavicular joints.

Some complications may be expected. There was one instance of a disfiguring prominence. In this case, the cast became loose, and undoubtedly the resulting abnormal bony prominence could have been avoided, if the cast had been reapplied snugly about the fracture. There was one case of delayed union. In this instance, wide separation of the fragments with a question of interposition of soft tissue required preliminary treatment with tape traction applied to the arm for five weeks, in bed. This fracture healed, after eight weeks, with massive callus which later was absorbed sufficiently to give a good cosmetic result.

Another patient was treated by tape traction in bed, because of the presence of a large comminuted third fragment which was widely separated and had to be manipulated into alignment. In this type of case, it is suggested that tape traction be applied to the arm, and the arm held in 90 degrees of abduction, in addition to the use of the cast. The patient may be allowed to lie down or sit up in bed, with the back rest adjusted accordingly. After three weeks the tape traction is released, and the patient is permitted to be up and about without sling or support. The cast is used for a total of six to eight weeks, depending upon the x-ray evidence of sufficient callus.

Two patients with casts were necessarily treated as bed patients because of other severe injuries. One patient had an amputated foot and a skull fracture, and the other a fractured pelvis. Both patients were kept comfortable, and required less nursing care after immobilization of the clavicle in plaster. Immobilization in such cases should be maintained from five to eight weeks, according to roentgenographic proof of sufficient new-bone formation.

In one patient, there was wide separation and overlapping of oblique fragments for a distance of one inch. Following treatment by this method, he was able to do calisthenic "push ups" from the floor in seven weeks.

Some of the advantages of conservative treatment by plaster cast are:

1. The fracture is better immobilized, thus relieving the patient of painful crepitation during respiration.

2. The weight of the cast is carried on the proximal fragment by means of the thick pressure pad instead of on the shoulder, thus aiding in the reduction of the fracture.

3. The axillary crutch principle is not used, and there is, therefore, no danger of circulatory or nerve compression at the armpit.

4. Backward pressure exerted by the cast on the shoulders and forward pressure against the spine produce the three points of pressure relied upon to maintain abduction of the shoulders and reduction of the fragments.

5. No further attention is needed until the cast is removed six weeks later.

6. Freedom in the use of both arms and the ability to wear normal clothing over the device allows the men to return to their organization for light duty within a few days.

REFERENCES

KINI, M. G.: A Simple Method of Ambulatory Treatment of Fractures of the Clavicle. J. Bone and Joint Surg., XXIII, 795, Oct. 1941.

MURRAY, GORDON: A Method of Fixation for Fracture of the Clavicle. J. Bone and Joint Surg., XXII, 616, July 1940.

YOUNG, C. S.: The Mechanics of Ambulatory Treatment of Fractures of the Clavicle. J. Bone and Joint Surg., XIII, 299, Apr. 1931.

CAUSES OF FAILURE IN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP

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The purpose of this study is to determine why some cases of congenital dislocation of the hip heal with perfect results, while the same treatment in others fails, and to outline some modifications in the classical treatment.

The material for this work was obtained from the extensive files of the Department of Orthopaedic Surgery of the State University of Iowa. All the cases were treated by or under the direction of Dr. Arthur Steindler. The records of 129 patients with a follow-up of over four years were examined. Of these, twenty-three were males and 106, females. Eighty-five, or 66 per cent., of the cases were unilateral, and forty-four, or 34 per cent., were bilateral, making a total of 173 hips. Twenty-four, or 28.2 per cent., of the unilateral cases were on the right side and sixty-one, or 71.8 per cent., on the left. The longest follow-up was twenty-three years.

TYPES OF CONGENITAL DISLOCATION OF THE HIP

It is now well established, and has been pointed out by different authors during the past twenty years, that there are several types of dislocation of the hip, depending upon the period of the ontogenetic development in which the dislocation originates:

1. The embryonic dislocation, where the head develops out of the acetabulum;
2. The foetal dislocation, which takes place during the foetal period;
3. The natal dislocation, which originates during delivery and probably occurs more often in breech presentations;
4. The postnatal dislocation, which is the most frequent, takes place after birth, and is probably due to some congenital dysplastic local condition;
5. The subluxation, where, in spite of a shallow acetabulum and upward displacement of the head of the femur, a complete dislocation never occurs.

As most cases of dislocation of the hip are seen by the doctor after the first year of life, it is difficult to say *a posteriori* in which period in the development of the child the dislocation took place. To determine the type of dislocation will be of value in making a prognosis and indicating the treatment.

The most valuable aid in determining the type of dislocation is furnished by roentgenograms. All those taken in this Clinic include both hips, with the legs in neutral position, and the x-ray tube thirty-six inches above the body focused at the mid-line half-way between the pubis and the bi-iliac line. Errors can easily be made in the interpretation of the roentgenographic shadows, as a different impression can be gained with a slight variation in the angle of incidence of the roentgen rays. Great care was taken to avoid such errors.

In the interpretation of the roentgenograms, it is important to bear in mind that at birth the greatest part of the acetabulum is cartilaginous. The acetabular roof is represented on the roentgenogram by a line, which is the lower border of the ossification center of the os ilium. The anterior and posterior walls of the acetabulum are cartilaginous and do not cast any shadows. If the head of the femur is in the acetabulum, as occurs normally, the roof becomes concave and casts a shadow as a dense, slightly concave line. As time goes on, the ossification of the acetabulum progresses, and, at the end of the first

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year, a lighter shadow can be seen close to this dense line. This lighter shadow represents the spread of the ossification through the anterior or posterior walls of the acetabulum, next to the roof. These walls will not become completely ossified until puberty (See Figures 2-A, right hip, and 2-C, left hip).

We have classified our cases into three groups: prenatal dislocations, postnatal dislocations, and doubtful cases.

FIG. 1-A

FIG. 1-B

FIG. 1-C

Three cases of prenatal dislocation.

Fig. 1-A: A girl, two months old, with bilateral dislocation and convex acetabular roof. The secondary acetabulum is fairly well developed.

Fig. 1-B: A girl, six months old, with dislocation of the right hip.

Fig. 1-C: A boy, four months old, with multiple arthrogryposis and bilateral dislocation.

Prenatal Dislocations

In this group have been included the cases where the dislocation was present at birth, and roentgenograms indicate that the head of the femur never was in the acetabulum, or that it may have been dislocated for several months before delivery (Figs. 1-A, 1-B, and 1-C).

In the prenatal dislocations, since the head of the femur does not develop inside the acetabulum, the acetabular roof is not concave, but is flat and usually convex. Because of the lack of pressure of the head, the line representing the acetabular roof in the lower portion of the ossification center of the ilium does not become denser. The acetabular roof is not concave, and the lighter shadow, representing the anterior or posterior walls of the acetabulum, which is normal after the first year of life, will not appear.

In the prenatal cases, the ossification center of the head appears late. The secondary acetabulum usually develops above the primary acetabulum, and has no relation to it. The head of the femur is usually stable in this secondary acetabulum, because it has been dislocated since the early period of development. For this reason, the secondary acetabulum is generally well developed after the first year of life, and is surrounded by ossified borders, even in its upper aspect.

In this series, twelve, or 9.3 per cent., of the cases were of the prenatal type; seven were unilateral and five, bilateral. Four patients of this group were males, and eight, females. Four of these twelve patients showed generalized arthrogryposis. Most of the prenatal cases were anterior dislocations.

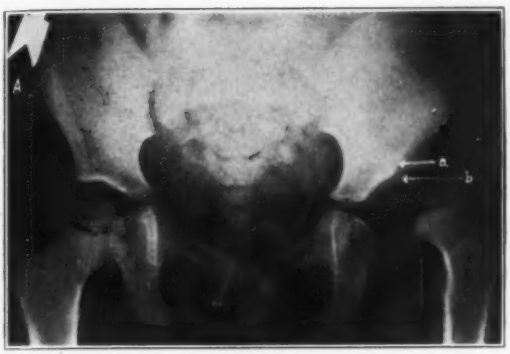

FIG. 2-A

FIG. 2-B

FIG. 2-C

FIG. 2-D

Four cases of postnatal dislocation of the hip showing *bilabiation* of the acetabular roof. The secondary acetabulum develops as an upward prolongation of the primary acetabulum.
a represents the continuation of the upper portion of the acetabular roof.
b represents the continuation of the ossified anterior wall of the acetabulum.
c represents a "cut-out" defect on the right hip in Fig. 2-D.

Postnatal Dislocations

Postnatal dislocations were the most numerous. Eighty-seven, or 68.3 per cent., were classified in this group. Sixty-one were unilateral cases, and twenty-six, bilateral; twelve were males and seventy-five were females.

The patients in this group are born with a dysplastic hip characterized by the triad of symptoms described by Putti and Hilgenreiner:

1. Obliquity of the acetabular roof;
2. Delay in the appearance of the nucleus of the head of the femur;
3. Ectopy of the femoral epiphysis.

Putti has called the period in which these signs are present the "predislocation stage". During this stage, the head is still in the acetabulum, and it has been shown by Faber and others that, although the predislocation is somewhat frequent in infants, this stage is overcome without treatment, and, as the child grows older, the hips develop normally. If the dislocation occurs, it takes place slowly and progressively, usually during the entire first year of life, and becomes well established when the patient begins to walk. The process that characterizes these dislocations is the upward and somewhat backward progressive sliding of the femoral head over the surface of the sloping acetabular roof, and, later on, over the lateral aspect of the iliac wing. In some cases, the head slides directly upward, and in others markedly backward, creating a variety of types of postnatal dislocation. In most of these postnatal dislocations, roentgenograms show what the author calls the *bilabiation* of the acetabular roof (Figs. 2-A, 2-B, 2-C, and 2-D). The denser line, repre-

FIG. 3-A

Subluxation on the left; complete postnatal dislocation on the right.

FIG. 3-B

Subluxation on the right.

senting the upper portion of the acetabular roof, ascends laterally and somewhat backward until it is lost in the lateral aspect of the iliac wing. The posterior wall of the acetabulum does not develop, because of the backward displacement of the head and neck. The ossification of the upper portion of the anterior wall of the acetabulum casts a lighter shadow, which follows the anterior aspect of the femoral head in its ascension. The roentgenogram shows, then, two shadows spreading upward from the primary acetabulum. On stereoscopic roentgenograms it appears as though the ossified acetabular roof opened its lateral margin, forming two lips while the head was sliding upward. In the posterior dislocations, the bilabiation is easily seen, while in the upward and anterior dislocations this sign may be absent.

When the head passes above the level of the labrum glenoidale, a dislocation takes place and a secondary acetabulum develops as an upward prolongation of the primary acetabulum. The limitations of the secondary acetabulum are indicated anteriorly by the lighter shadow which is the prolongation of the ossified anterior wall of the primary acetabulum, and inwardly by the continuation of the denser shadow which represents the upper portion of the primary acetabulum. In some cases, once the head of the femur has dislocated, the superior rim of the primary acetabulum, which has been flattened to allow the upward sliding of the femoral head, ossifies anew, creating a separation between the primary and the secondary acetabulum. In other cases, without any apparent reason, the acetabular rim does not re-ossify; and, in the roentgenogram, a continuation between the primary and the secondary acetabulum persists. In the roentgenogram, the secondary acetabulum usually has no upper limit.

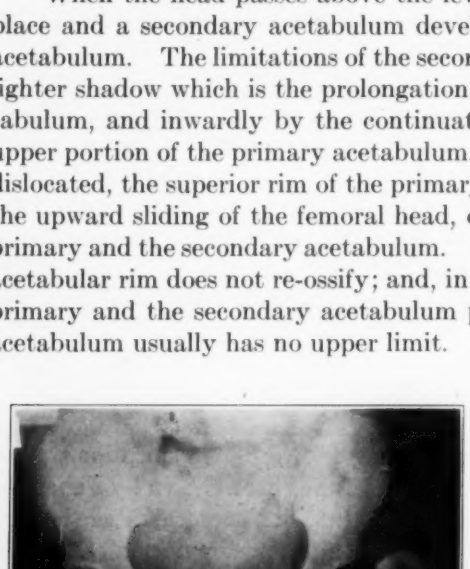

FIG. 4-A

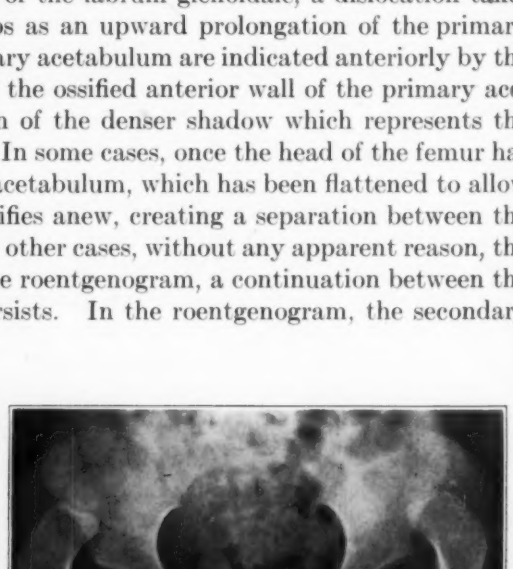

FIG. 4-B

Two cases of congenital dislocation where the secondary acetabulum is completely separated from the primary acetabulum. The primary acetabulum is fairly well developed, but *bilabiation* of the acetabular roof is not present.

The longer the dislocation exists, the wider the medial wall of the primary acetabulum becomes. The prenatal dislocations show a wider medial wall than the postnatal dislocations. The so-called U-shaped shadow is formed mainly by the inner and outer surfaces of the medial wall of the acetabulum below the Y cartilage. The U shadow is narrow and well formed in the normal acetabulum; it is wide in the postnatal dislocations; and it does not exist in the prenatal dislocations.

The head of the femur in the postnatal cases usually retains its normal round shape.

In some cases of predislocation, the head of the femur ascends very slowly, and, probably because of the reaction of the ligamentous apparatus of the hip, the head never slides over the labrum glenoidale. Although the acetabulum becomes deformed and is very shallow, a complete dislocation does not occur and a subluxation is established (Figs. 3-A and 3-B).

Doubtful Cases

Twenty-nine, or 22.5 per cent., of the cases in this series cannot be placed in either the prenatal or the postnatal group. Sixteen of these doubtful cases were unilateral, and thirteen, bilateral. Six patients were male and twenty-three were female. It is believed that some of these dislocations originated in a birth trauma; that others took place during the last months of intra-uterine life; and that still others are probably anterior dislocations of the postnatal type with a well-ossified rim of the primary acetabulum. It is characteristic of this group that the primary acetabulum is fairly well developed, and shows roentgenographic evidence that the head was in the socket during some period of intra-uterine life. The secondary acetabulum is usually well formed, and is completely separated from the primary acetabulum, seeming to indicate that this dislocation did not occur by progressive upward sliding of the femoral head. The bilabiation sign is absent. These cases are called doubtful because roentgenograms show varied characteristics, and it has not been possible to determine when and how the dislocation occurred (Figs. 4-A and 4-B).

There was one case of unilateral predislocation in a male.

The study of this series has shown that the classification of the cases of congenital dislocation of the hip into three groups is of the utmost importance for prognosis and for treatment. In not a single case of the seventeen prenatal dislocations treated did a normal hip develop. In 76.5 per cent. treated by different methods, bad results followed, and the results in the remainder were just fair (See Table IV). From this it may be concluded that the prenatal dislocations should not be reduced, unless the patient is seen during the first months of life. If these cases are left alone, a secondary acetabulum will develop which will provide a good functional result. In the prenatal dislocations, the primary acetabulum practically does not exist. When we try to reduce a hip of this type after the first year of life, we simply remove the head from a more or less well-developed secondary acetabulum to put it in front of the Y cartilage, where a primary acetabulum does not exist, and where none of the elements required to form a joint is present.

In the postnatal dislocations and the doubtful cases, the head develops and remains in the primary acetabulum for a certain period. During the first years of life, the primary acetabulum retains the potentialities to rebuild a new joint. All these cases must be reduced, because the secondary acetabulum is poorly formed and will never provide the functional result that a well-developed primary acetabulum will give after successful treatment. In many doubtful cases reduction is difficult, but the retention of the head in the primary acetabulum is easy and very good results are obtained.

The author believes the abduction apparatus, advocated by Putti as an early treatment for congenital dislocation of the hip, will give good results only if applied during the predislocation stage. The application of this apparatus is, in the author's opinion, useless on hips of the postnatal group which have already dislocated, or on the prenatal and doubtful cases. It is impossible to obtain statistics on the results of the treatment of the

TABLE I

EPIPHYSITIS OF THE REDUCED HIP

Condition	No.	Per Cent.	Result of Epiphysitis on the Final Shape of the Head		
			Regular	Flat	Somewhat Irregular
No epiphysitis	93	53.8	—	—	—
Cystic atrophy	66	38.2	20	33	13
Fragmentation of the head	14	8.0	1	7	6
Totals	173	100.0	21	40	19

predislocation by means of the abduction apparatus, because many predislocations heal without treatment, and it is impossible to say *a priori* which cases will dislocate.

Putti stated that most predislocations are bilateral. After the first year of life, unilateral dislocations are more frequent than bilateral. In this series, 66 per cent. of the cases were unilateral. Due to unknown reasons—mechanical, biological, or both—one hip overcomes the predislocation stage and develops normally, while, in the other hip, the predislocation results in a complete dislocation. The patients with unilateral dislocation had some potential factor for a spontaneous cure of the congenital dysplasia. This is probably the reason why the unilateral cases heal with better results than the bilateral cases.

It is impossible from study of the roentgenograms to draw any conclusions as to the variations of the angle of anteversion of the femoral neck, which is usually manifested on the roentgenogram by a coxa valga (Figs. 2-A, 2-B, 2-C, and 2-D). In his recent and interesting publication, Badgley expresses the opinion that anteversion of the head and neck of the femur is a necessary developmental change, caused by the torsional forces which internally rotate the limb buds. "The anteversion develops normally during foetal life, and diminishes after birth." Badgley explains the persistence of the anteversion in the dysplastic hips "by an embryonic interference in the maintenance of the reciprocal relationship of the head of the femur to the socket during the rotation of the limb buds". This author gives to the anteversion great value as a determining factor of the dislocation.

The importance of the anteversion of the femoral neck in the maintenance of the reduction is still a matter of discussion. In this series, there were twenty-eight redislocations and four subluxations. Only four redislocations and two subluxations were clearly due to the anteversion of the femoral neck, but probably the anteversion plays an important rôle in the maldevelopment of the hip after the period of immobilization.

The So-Called Normal Hip in Unilateral Cases

In the eighty-five cases of unilateral dislocations, the "normal" hip was well formed in forty-seven cases (55.3 per cent.). In the remainder, the "normal" hip showed some defect as a proof of its congenital dysplasia. Eighteen patients (21.2 per cent.) had a poorly developed and shallow acetabulum (Fig. 7-A). Twenty cases (23.5 per cent.) showed a "cut-out" defect in the outer margin of the upper rim of the acetabulum,—that is, the calcified acetabular roof does not end externally in a well-defined angle, but in this lateral region there is a "cut-out" defect in the ossification (Fig. 2-D). The femoral head of the "normal" hip in the unilateral cases was always regular in shape.

To recognize the defects of the "normal" hip in unilateral cases is of utmost importance. The defective "normal" hip should be treated by positioning the leg in abduction and inward rotation during the whole period of treatment of the dislocated hip. Not to do so may bring about a good result in the dislocated hip and a poor result in the "normal" hip.

FIG. 5-A

FIG. 5-B

Two cases of epiphysitis of the reduced hip.
Fig. 5-A: Cystic atrophy of the femoral head is more visible on the left.
Fig. 5-B: Showing fragmentation of the left femoral head.

POSTREDUCTION CHANGES

When a dislocated hip is reduced, the femur is brought downward with all its muscle and ligament attachments, until the femoral head is placed in the primary acetabulum. Although the primary acetabulum contained the head of the femur during early life, its qualities as a cotyloid cavity were lost after the head became dislocated. After reduction, the femoral head remains in a badly built cavity which has deficient or no synovial lining, and which is partly occupied by a cushion of hypertrophied fat tissue. During the manoeuvres of reduction, some vessels of the capsule and its ligaments are torn off, and the ligamentum teres may be lacerated. These changes occur suddenly and determine the production of a series of alterations in the elements of the reduced hip which play an important rôle in the maldevelopment of the new hip joint. The femoral head is affected most.

Epiphysitis of the Reduced Hip

Under this title, Putti includes all the changes which occur in the femoral head after reduction. Freund divided this group into two different types of lesions which he called osteochondritis and arthritis. Schede believes that the fragmentation of the epiphysis is but a sign of re-ossification of the femoral head, usually without pathological significance.

Pathological examinations of reduced hips are very scarce, and for this reason epiphysitis can be studied only from a roentgenographic point of view.

From the study of this series, the author believes it will be useful to divide the changes of the reduced femoral head into two groups:

1. *Cystic Atrophy of the Ossified Nucleus of the Head:* This lesion consists of multiple cysts in an atrophic femoral head. The cysts are of different sizes and are more frequently seen in the subchondral plate, but they can also occur in the center of the epiphysis. The metaphysis is not involved in the process. This lesion is rather frequent in this series, and can be seen in the roentgenogram six or seven months after reduction (Figs. 5-A and 8-C). The damaging effect of this lesion, with reference to the final shape of the head, varies; no rules can be given, although the earlier it appears, the worse is the prognosis. In this series, there were sixty-six such lesions (38.1 per cent. of the total number of hips). In twenty of these sixty-six cases, a normal hip developed; in thirteen, some irregularity of the head resulted; and in thirty-three, the head was considerably flattened, and in a few of these cases, completely destroyed.

2. *Fragmentation of the Ossified Nucleus of the Head:* This lesion is somewhat similar to Legg-Perthes disease, although there is usually no mass necrosis of the head; the metaphysis is not involved; and the head fragments into small pieces. The fragmentation may develop at any time during treatment, but in this series it appeared either during the first two months after reduction or after the patient began to walk. In the early cases, the

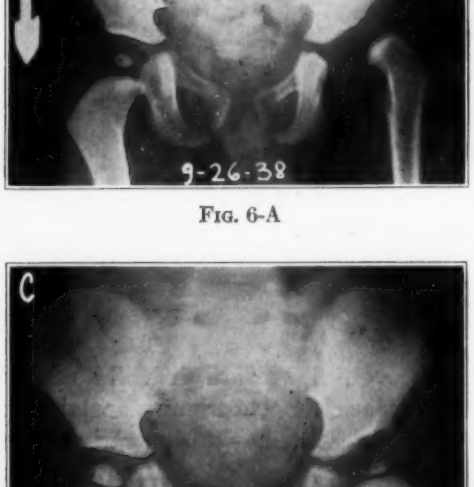

FIG. 6-A

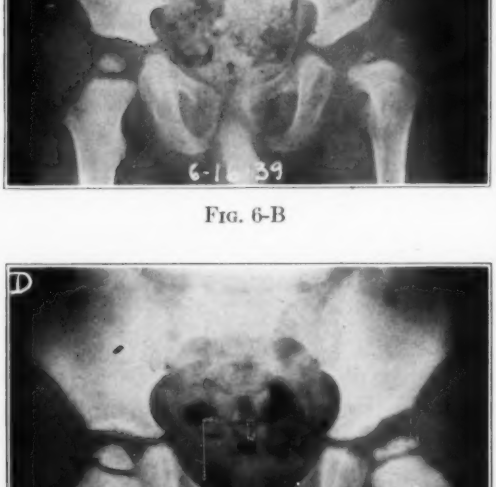

FIG. 6-B

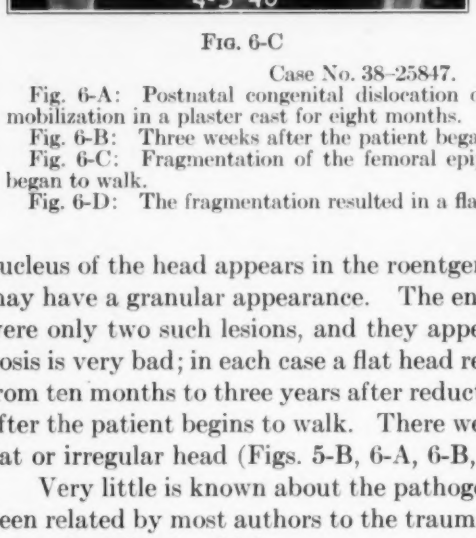

FIG. 6-C

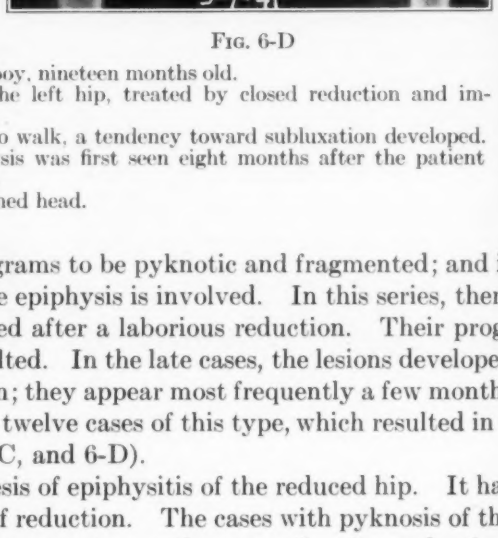

FIG. 6-D

Case No. 38-25847. A boy, nineteen months old.

Fig. 6-A: Postnatal congenital dislocation of the left hip, treated by closed reduction and immobilization in a plaster cast for eight months.

Fig. 6-B: Three weeks after the patient began to walk, a tendency toward subluxation developed.

Fig. 6-C: Fragmentation of the femoral epiphysis was first seen eight months after the patient began to walk.

Fig. 6-D: The fragmentation resulted in a flattened head.

nucleus of the head appears in the roentgenograms to be pyknotic and fragmented; and it may have a granular appearance. The entire epiphysis is involved. In this series, there were only two such lesions, and they appeared after a laborious reduction. Their prognosis is very bad; in each case a flat head resulted. In the late cases, the lesions developed from ten months to three years after reduction; they appear most frequently a few months after the patient begins to walk. There were twelve cases of this type, which resulted in a flat or irregular head (Figs. 5-B, 6-A, 6-B, 6-C, and 6-D).

Very little is known about the pathogenesis of epiphysitis of the reduced hip. It has been related by most authors to the trauma of reduction. The cases with pyknosis of the femoral epiphysis, which appears on roentgenograms two or three months after reduction, can reasonably be imputed to the trauma of reduction, but a fragmentation of the femoral epiphysis, which develops many months or years after reduction, appears too late for its cause to be laid to the reduction trauma. As many of these cases of fragmentation of the femoral epiphysis developed a few months after the patient began to walk, repeated trauma through walking with the head placed in an irregular and poorly developed acetabulum is more likely to be the cause of the fragmentation of the head.

The cystic atrophy of the femoral head appears on roentgenograms after the sixth or seventh month of reduction. Probably the lesion shown on the roentgenogram is a late manifestation of a process which originates right after reduction. The primary acetabulum, which is a badly developed cavity without synovia, offers poor nutritional conditions for the cartilage of the reduced head, and the importance of this cartilage in the ossification of the femoral epiphysis is known. The author believes the inferior viability

FIG. 7-A

FIG. 7-B

FIG. 7-C

FIG. 7-D

FIG. 7-E

FIG. 7-F

Case No. 38–25723. Congenital dislocation of the left hip and shallow acetabulum on the right, in a two-year-old girl.

One month and a half after walking there was fragmentation of the femoral head on the left and a tendency toward subluxation (Fig. 7-B). The acetabulum was very shallow. In spite of no after-treatment, the head became well centered and the hip developed normally (Fig. 7-F).

of this cartilage and the tearing of capsular vessels during reduction to be the most likely cause of the cystic atrophy seen on the roentgenogram.

Postreduction Changes of the Acetabulum

In this series, there are two types of lesions of the acetabular roof: (1) osteosclerosis, and (2) cystic atrophy. Osteosclerosis of the acetabulum developed in sixty-five of the 173 hips (37.6 per cent.). This condition appeared from one to three years after reduction, and always interfered with the formation of a normal acetabular roof. The sooner the sclerosis appears, the poorer is the prognosis. The cystic atrophy in the acetabular roof is an earlier and rarer lesion. Cystic atrophy of the acetabulum developed in only six (3.4 per cent.) of the cases, appearing from six to ten months after reduction. This lesion usually disappears and has no effect on the final result. In 102 (59.0 per cent.), the acetabulum was normal.

RESULTS

The treatment of congenital dislocation of the hip, which was used in this series, has not changed essentially since publication of the article "Congenital Dislocation of the Hip" by Steindler, Kulowski, and Freund in 1935. "The bloodless reduction was accepted as the method of choice within the upper age limits of five for bilateral and six for unilateral cases. . . . The open operations were adopted not as a competition but as a supplementary method to the closed reduction. It was made contingent universally on failure of the closed method to accomplish reduction or retention of the hip, or both. . . . The palliative operative methods [shelf operation and osteotomies], again, depend for their indications on failure of both closed and open reduction. . . ." The Ridlon modification of the Paci-Lorenz method for reduction was used. The hip was immobilized for three months in the Lorenz position followed by three additional months with the hip in the Lange position. "Walking exercises were initiated at an average from six to eight months after immobilization. It is the policy of this Clinic not to be too orthodox but to fit the manoeuvre of reduction and the position of immobilization as much as possible to the individual case."

Of the 173 hips studied, 103 were treated by closed reduction alone; twenty required open reduction; forty-five necessitated shelf operations; one was treated by means of an abduction splint; and four had subtrochanteric osteotomies.

In order to evaluate the results obtained in this series, the cases were divided into three groups: (1) the prenatal group, (2) the doubtful group, and (3) the postnatal group. The standard chosen for this evaluation was taken from the monograph by Severin, published in 1941. The number of cases in each group is shown in Table IV.

The author's standards for the functional results are as follows (See Table III):

1. No symptoms;
2. Slight pain in the hip on excessive walking;
3. Limp, but free motion and no pain;
4. Limp and limitation of motion, but no pain;
5. Limp and pain;
6. Limp, limitation of motion, and pain.

The functional results in young patients are excellent in all cases of anatomical Groups I and II, and in most cases of Group III. The important difference is that the patients of

TABLE II

ANATOMICAL RESULTS OF TREATMENT *

Group	Closed Reduction	Open Reduction	Shelf Operation
I. Well-developed hip joints	12	0	0
II. Moderate deformity of the femoral head, neck, or acetabulum in an otherwise well-developed joint	38	3	4
III. Dysplasia, not subluxation	31	10	16
IV. Subluxation	8	3	4
V. Femoral head in a secondary acetabulum in the upper part of the primary acetabulum	6	2	15
VI. Redislocation	8	2	5
Totals	103†	20	44‡

* One patient who was treated in an abduction splint and four who had subtrochanteric osteotomies are not included in this table, or in Table III.

† In thirty-two cases, an initially attempted closed reduction failed; open reduction or a shelf operation was thus necessary.

‡ One patient, not included in this total, died a few hours after a shelf operation.

TABLE III

FUNCTIONAL RESULTS OF TREATMENT *

Functional Results	Closed Reduction	Open Reduction	Shelf Operation
1. No symptoms	47	4	0
2. Slight pain in the hip on excessive walking	8	2	1
3. Limp, free motion, no pain	20	4	7
4. Limp and limitation of motion, but no pain	16	4	16
5. Limp and pain	10	3	11
6. Limp, limitation of motion, and pain	2	3	9
Totals	103†	20	44‡

* † ‡ See footnotes to Table II.

Group I will have good and symptomless hip joints all their lives, whereas the patients of Groups II and III will show, usually at the age of puberty, symptoms referable to defective hips. Schede divides the results in the treatment of congenital dislocation of the hips into primary results and end results. The primary results are those obtained before puberty, and the end results are those seen after puberty.

If the functional and anatomical end results are compared, it can be said that, as a whole, during the first years following treatment, the number of good functional results surpasses the number of good anatomical results,—that is, many hips of Groups II and III will be included in functional results of Group I. Later this relation changes, and the functional results become poorer in the hips of the anatomical Groups II and III. The hips of the anatomical Group I remain with a permanent good functional result.

The results of the cases treated by closed reduction alone are given in Tables II and III.

As can be seen in Table IV, the best results were obtained in the cases of postnatal dislocation treated by closed reduction.

In any type of congenital dislocation, the cause of the failure of treatment can be found at one of the following times:

1. At the time of reduction;
2. During immobilization;
3. After immobilization.

1. *Failure at the Time of Reduction:* Those cases which could not be reduced in this series were the prenatal dislocations, some of the doubtful cases, and a few of the postnatal dislocations. Most of these patients, whose hips could not be reduced by the closed method, were operated upon; and, except for two cases of hour-glass constriction and four cases of anteversion of the neck, no clear reason could be found to explain the irreducibility, except the lack of development of the primary acetabulum in the prenatal cases. Probably due to the policy at this Clinic of "refraining from strenuous and overforceful reduction", not one traumatic accident and only two cases of nuclear pyknosis of the head of the femur can be attributed to the manoeuvres of reduction.

2. *Failure during Immobilization:* Only nine cases became dislocated during treatment, and only one was subluxated. By far the most frequent cause of failure in the treatment during immobilization is the epiphysitis of the reduced hip. The problem has already been studied, and it has been seen how frequently the cystic atrophy and the fragmentation of the femoral head result in a flattening of the head, and thus affect the final result.

3. *Failure after Immobilization:* Twenty-eight redislocations occurred, nine (32 per cent.) of them during the period of immobilization, and seventeen (61 per cent.) during the

TABLE IV

SHOWING ANATOMICAL RESULTS OF TREATMENT OF VARIOUS TYPES OF DISLOCATION

Anatomical Results and Treatment	Type of Dislocation										
	Prenatal			Doubtful			Postnatal			Predislocation	
	No. of Cases		Per Cent.	No. of Cases		Per Cent.	No. of Cases		Per Cent.	No. of Cases	Per Cent.
I. Well-developed hip joints	0			3			12				
Closed reduction		0			3			12		1	100.0
Open reduction		0			0			0			
Shelf operation		0			0			0			
II. Moderate deformity of the femoral head, neck, or acetabulum in an otherwise well-developed joint	1		5.9	7		23.3	31		38.4		
Closed reduction		0			5			26			
Open reduction		1			1			3			
Shelf operation		0			1			2			
III. Dysplasia, not subluxation	3			16			39				
Closed reduction		1			6			25			
Open reduction		2	17.6		4	37.2		4	34.8		
Shelf operation		0			6			10			
IV. Subluxation	2			3			14				
Closed reduction		1			3			11			
Open reduction		1			0			0			
Shelf operation		0			0			3			
V. Femoral head in a secondary acetabulum in the upper part of the primary acetabulum	5			5			10				
Closed reduction		2	76.5		1	39.5		3	26.8		
Open reduction		0			0			0			
Shelf operation		3			4			7			
VI. Redislocation	6			9			5				
Closed reduction		3			2*			3*			
Open reduction		2			1			1			
Shelf operation		1			6			1			
Totals	17	17	100.0	43	43	100.0	111	111†	100.0	1	100.0

* Of the four patients who had subtrochanteric osteotomies, two were of the doubtful type and two of the postnatal type; they are included in the closed reduction group of the anatomical result VI, redislocation.

† One patient with a postnatal dislocation died after a shelf operation.

FIG. 8-A

FIG. 8-B

FIG. 8-C

FIG. 8-D

FIG. 8-E

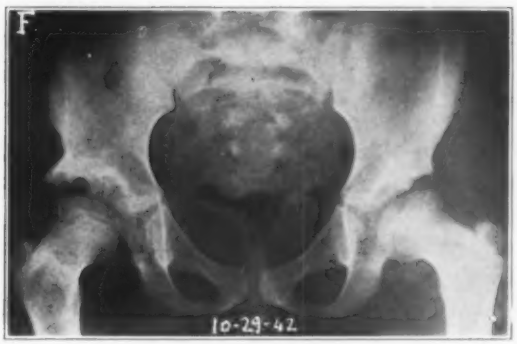

FIG. 8-F

Case No. 38–19238. Three-year-old girl.

Fig. 8-A: Postnatal type of bilateral congenital dislocation. The patient was treated by immobilization in a plaster cast for six months.

Fig. 8-B: Two weeks after patient began to walk, a tendency toward redislocation began to develop in both hips.

Fig. 8-C: The tendency toward redislocation increased. There was cystic atrophy of both femoral heads, but more on the left.

Figs. 8-D and 8-E: Redislocation on the right progressed. On the left, the head became better centered. On September 27, 1939, a shelf operation was performed on the right hip.

Fig. 8-F: Showing a Group-III anatomical result bilaterally. The Trendelenburg sign was positive on the right and negative on the left.

first three months of mobilization following treatment. Only two redislocations (7 per cent.) took place after that period; one of these was due to poliomyelitis with involvement of the hip muscles. Four subluxations occurred after a successful closed reduction,—one during the period of immobilization, one during the first three months of mobilization, and two after three months.

From a study of this series, it is evident that in many cases of postnatal dislocation, a successful closed reduction is obtained, and a good central position of the femoral head remains during the whole period of immobilization. This determines the beginning of the

development of a well-formed acetabular roof and acetabular cavity. After the immobilization, a short period of physiotherapy and exercises for the legs is followed by walking. It is during the first two or three months of walking that the femoral head is seen to become displaced upward and outward, tending to subluxate. The acetabular roof, which is fairly well formed at the end of the immobilization period, now becomes shallow and sometimes fragmented. In some patients, this period of danger of redislocation is successfully overcome, and a good hip develops (Figs. 7-A through 7-F). In other cases, the upward displacement of the head continues and brings about a dysplasia of the hip joint, a subluxation, or a redislocation (Figs. 8-A through 8-F).

Except for the prenatal dislocations and a few dubious and postnatal cases, which could not be reduced, the greatest number of failures in the treatment of congenital dislocation of the hip is to be found in:

1. Epiphysitis of the femoral head;
2. Tendency of the head to become subluxated, which occurs at the beginning of the walking exercises.
3. Osteosclerosis of the acetabular roof.

In each dislocated hip, there is, of course, a personal factor to explain the different response obtained from the same treatment given under similar circumstances. It is not possible to influence this personal factor of obscure biological origin. How important this uncontrollable personal factor is, it is difficult to say, but from the study of this series, the author believes that, in general, the possibilities of a well-directed treatment are very great. In several cases of bilateral dislocated hip of the same type and of similar character, a well-developed hip has resulted on one side and a dysplasia or redislocation on the other. Some failure in the treatment of the dysplastic hip could be observed in many cases as proof that the difference in the result was not totally due to a personal factor.

Modifications of the Treatment

It is now universally admitted that the best results in the treatment of congenital dislocation are to be obtained with the application of an early treatment, if possible during the predislocation stage. The greatest possibilities of rebuilding a perfect joint are found during the first year of life. As the patient grows older, these possibilities decrease very rapidly. The difficulties encountered in the application of such a treatment are known. Except in rare circumstances, the diagnosis of a predislocation is never made. It is interesting to note that most of the early diagnoses are made in cases of prenatal dislocations, where the early treatment can fail and where an abduction splint is useless.

Several important modifications of the classical treatment of the dislocated hip have lately been introduced by Waldenström, Schede, Gaugele and Kienzle, Faber, and others.

At the present time, because of the difficulty of an early diagnosis, if better results are to be obtained in the treatment of congenital dislocated hips, we shall have to direct our efforts to diminishing the incidence of epiphysitis and to establishing a careful and prolonged after-treatment to favor the development of the acetabular roof. It was noted how frequently cystic atrophy of the femoral epiphysis occurs, and that a flattened head results in 50 per cent. of these cases. The cystic atrophy starts to develop from the fifth to the seventh month of immobilization, and progresses until the removal of the cast. The longer the immobilization, the greater and more frequent is the cystic atrophy. As has been mentioned, the author believes this lesion to be related to the poor biological condition of the primary acetabulum, where the femoral head is placed after reduction. The best conditions for the head will be provided by an early development of the new hip joint with all its components, but mainly the development of the synovial lining. In a baby, a good part of the femoral head is cartilaginous, and we know how much the nutrition of the cartilage depends upon the synovial fluid.

It seems logical that a joint, which is the main organ of motion, will develop better

with motion than with rest. The retention of the head in the primary acetabulum should be the principal aim of treatment during the first months after reduction. As soon as the danger of redislocation has disappeared, the rebuilding of the new hip joint will be better accomplished by the establishment of controlled motion.

The etiology of the fragmentation of the nucleus of the head is still very obscure, as is that of Legg-Perthes disease itself. The early pyknosis of the femoral head, due probably to the trauma of reduction, will be avoided if care is taken in the manoeuvres of reduction. It remains to be seen whether a well-directed and prolonged functional treatment, which avoids undue trauma to the newly formed joint, will limit the late cases of fragmentation of the head which usually appear a few months after the patient begins to walk.

A properly developed acetabular roof is necessary for a well-built hip joint. In many cases, the femoral head adopts a position of subluxation for a certain period when the patient begins to walk. In some cases, the subluxation develops into a complete dislocation; in others, it results in a dysplastic hip with a shallow acetabulum; and, in a few instances, the femoral head returns to occupy a central position in the acetabulum, and a good hip develops.

From the study of this series, it has been learned that the persistence of the Trendelenburg sign for more than two or three months after the patient has begun to walk indicates a poor prognosis. If the glutei do not recover and a positive Trendelenburg sign persists, the femoral head is subluxated on each step, due to the tilting of the pelvis, and the reconstruction of a good acetabular roof becomes impossible.

It has been said by different authors, and mainly by Krida and Badgley in this country, that one of the main causes of dislocation is the anteversion of the femoral head. Because of this anteversion, to obtain centralization of the femoral head in the acetabulum, it is necessary that the leg be maintained in inward rotation, and that outward rotation be avoided for a long period after treatment. The best way to accomplish that would be to strengthen the inward rotators of the hip which have been weakened during the period of immobilization.

We believe the postreduction treatment of the congenitally dislocated hip should be directed as follows:

1. Functional treatment should be started as early as possible to avoid or diminish epiphysitis of the reduced hip;

2. Prolonged, controlled, functional treatment, with the legs in abduction, should be carried out in order to secure the central position of the femoral head in the acetabulum, and to make possible a good development of the acetabular roof. Outward rotation of the legs should be avoided, but free inward rotation should be allowed, in order to stimulate the development of the inward rotators.

Directed by these principles and with Dr. Steindler's consent, one year ago we began to treat a group of congenitally dislocated hips in the following way:

1. The reduction of the hip is done following Ridlon's technique,—the method which has been used in this Clinic for many years.

2. A well-molded, bilateral, plaster hip spica is applied with the hip in 90 degrees of flexion and 60 to 70 degrees of abduction, in both unilateral and bilateral dislocations. This position is recommended by Waldenström in order to avoid overstrain on the adductors which "press the femoral head with great force against the acetabulum and the anterior part of the capsule". If the reduction is stable, the knee joints can be left free. If the head redislocates easily, the plaster cast must be extended below the knees. This position is maintained for from three to four months; and then, under anaesthesia, the legs are brought to Lange's position with as much inward rotation as possible. A bilateral long leg-hip spica is applied for two additional months.

3. Following the five or six months of immobilization, the controlled functional treatment is begun. With the object of (a) keeping the legs in abduction, (b) avoiding the

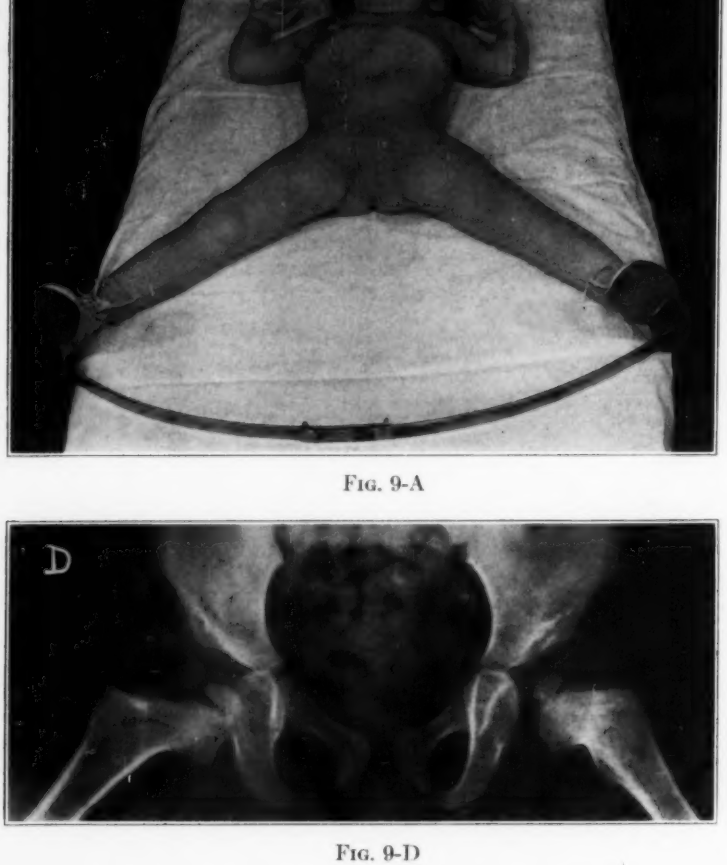

FIG. 9-A

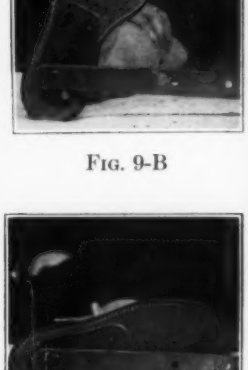

FIG. 9-B

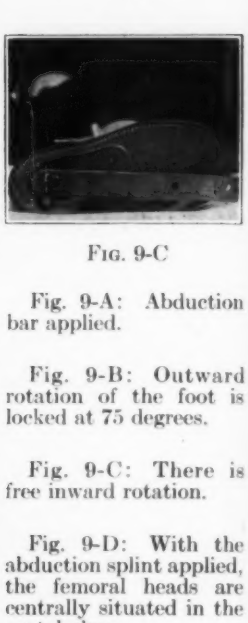

FIG. 9-C

Fig. 9-A: Abduction bar applied.

Fig. 9-B: Outward rotation of the foot is locked at 75 degrees.

Fig. 9-C: There is free inward rotation.

Fig. 9-D: With the abduction splint applied, the femoral heads are centrally situated in the acetabulum.

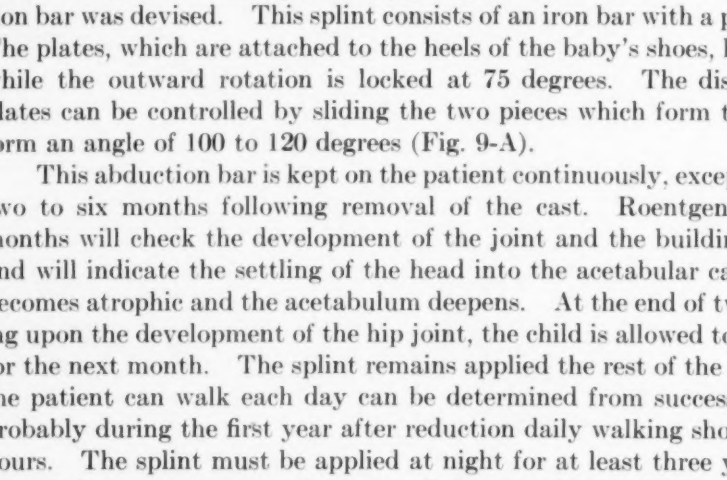

FIG. 9-D

outward rotation of the legs, and (c) giving them free motion in other directions, an abduction bar was devised. This splint consists of an iron bar with a plate inserted on each end. The plates, which are attached to the heels of the baby's shoes, have free inward rotation, while the outward rotation is locked at 75 degrees. The distance between these two plates can be controlled by sliding the two pieces which form the bar. The legs should form an angle of 100 to 120 degrees (Fig. 9-A).

This abduction bar is kept on the patient continuously, except for the daily bath, from two to six months following removal of the cast. Roentgenograms taken every two months will check the development of the joint and the building of the acetabular roof, and will indicate the settling of the head into the acetabular cavity as the fatty cushion becomes atrophic and the acetabulum deepens. At the end of two to six months, depending upon the development of the hip joint, the child is allowed to walk for two hours daily for the next month. The splint remains applied the rest of the day. The length of time the patient can walk each day can be determined from successive roentgenograms, but probably during the first year after reduction daily walking should not exceed two to six hours. The splint must be applied at night for at least three years following reduction, even if the roentgenogram shows a well-developed hip. We are dealing with a congenital deformity which has a strong tendency to persist.

No statistics can be given from the author's series, as sufficient time has not elapsed to evaluate results, but what has been observed so far is most encouraging.

The author's observations on open reduction and shelf operations are as follows: Open operation proved to be useful in several of the older cases, where an hour-glass constriction of the capsule, a too-long round ligament, or adhesions of the capsule to the wall of the iliac bone were the causes of the irreducibility. The hour-glass constriction and the adhesions of the capsule were late sequelae of old congenital dislocations. In no patient under four years of age were such conditions found, and consequently we conclude that, in young children, open operation is rarely indicated. Forty-five shelf operations were done in this series. A perfect anatomical result was rarely obtained (See Tables II and III). There were four cases in Group II. A dysplastic hip resulted in sixteen cases, and fifteen corresponded to Group V. The shelf operation was successful only in the cases where the femoral head could be well placed in the center of the acetabulum. The shelf with the head above the primary acetabulum gave a poor functional result.

SUMMARY

A study has been made of 129 patients with congenital dislocation of the hip, with the object of determining the causes of failure in the treatment of this condition.

The cases were divided into the following three groups:

1. Prenatal dislocations, where the dislocation is present at birth;
2. Postnatal dislocations, where the patient presents a predislocation at birth, which slowly progresses during the first year of life until it becomes a well-established dislocation when the patient begins to walk. The *bilabiation* of the acetabular roof shown on the roentgenogram is characteristic of most of these cases.
3. Doubtful cases, where both the primary and secondary acetabula are well developed, but where the roentgenogram shows them to be separated by a bony ridge. In these cases, it was impossible to determine how and when the dislocation took place.

Treatment in the prenatal cases generally resulted in failure. Putti's abduction splint is indicated only during the predislocation stage of the postnatal dislocations.

The anteversion of the femoral neck plays an important rôle in the maldevelopment of the hip after immobilization.

Two types of lesions indicative of the changes that take place in the femoral head after reduction are cystic atrophy and fragmentation. A flat or an irregular head may result from such lesions. Osteosclerosis and cystic atrophy may be observed in the acetabular roof.

An evaluation is made of the type of dislocation, and of the results obtained with different treatments.

The causes of failure in the treatment were studied at the time of reduction, during the period of immobilization, and after immobilization. Except for the prenatal dislocations, which have a poor prognosis under any treatment, the main causes of failure were found in: (1) the epiphysitis of the femoral head, (2) the tendency toward subluxation, which occurs at the beginning of the walking exercises, and (3) the osteosclerosis of the acetabular roof.

To improve the treatment, the author proposes to limit the period of immobilization in a plaster cast to from five to six months, this to be followed by a prolonged period of functional after-treatment, controlled with an *abduction bar*. The abduction bar was devised with the object of avoiding adduction and outward rotation of the hips, but allowing them free motion in other directions.

BIBLIOGRAPHY

BADGLEY, C. E.: Correlation of Clinical and Anatomical Facts Leading to a Conception of the Etiology of Congenital Hip Dysplasias. J. Bone and Joint Surg., XXV, 503, July 1943.

BAUER, FELIX: Functional Treatment of Congenital Dislocation of Hip-Joint. Proc. Royal Soc. Med., XXXIV, 215, 1941.

Burman, M. S., and Clark, H. C.: A Roentgenologic Study of the Hip Joint of the Infant in the First Twelve Months of Life. With Reference to Early Diagnosis of Its Congenital Dislocation. Am. J. Roentgenol., XLIV, 37, 1940.

Di Prampero, Antonio: Morfologia radiografica dell'anca così detta sana nella lussazione congenita unilaterale. Chir. d. Org. di Movimento, XXV, 1, 1939.

Drehmann, Fritz: Zur Frage der Spontanheilung der angeborenen Hüftverrenkung. Ztschr. f. Orthop., LXIX, 410, 1939.

Faber, Alexander: Zur Frage der Spontanheilung der angeborenen Hüftverrenkung. Jahresk. f. ärztl. Fortbild., XXX, 19, Dec. 1939.

Freund, Ernst: Zur Frage der Femurkopfverunstaltung nach unblutig eingerenkten angeborenen Hüftgelenksluxationen. Fortschr. a. d. Geb. d. Röntgenstrahlen, XLIII, 131, 1931.

Gaugele, und Kienzle, L.: Die Erfolge bei der Behandlung der Sogenannten angeborenen Hüftgelenkverrenkung. Deutsche Ztschr. f. Chir., CCXLV, 214, 1935.

Gill, A. B.: An Evaluation of Present-Day Methods of Dealing with Congenital Dislocation of the Hip. J. Bone and Joint Surg., XVIII, 487, Apr. 1936.

End Results of Bloodless Reduction of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XXV, 1, Jan. 1943.

Hart, V. L.: Primary Genetic Dysplasia of the Hip with and without Classical Dislocation. J. Bone and Joint Surg., XXIV, 753, Oct. 1942.

Hilgenreiner, H.: Zum angeborenen Charakter der "sogenannten" angeborenen Hüftverrenkung. Ztschr. f. Orthop., LXV, 58, 1936.

Zur angeborenen Dysplasie der Hüfte. Ztschr. f. Orthop., LXIX, 30, 1938.

Weiterer Beitrag zur Lehre und Behandlung der angeborenen Hüftverrenkung, Fort mit dem Gipsverband! Ztschr. f. Orthop., LXX, 212, 1940.

Korvin, Helmut: Über die echte oder teratologische angeborene Hüftluxation. Ztschr. f. Orthop., LXVIII, 33, 1938.

Krida, Arthur: A New Departure in the Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XIII, 811, Oct. 1931.

McCarroll, H. R., and Crego, C. H., Jr.: Primary Anterior Congenital Dislocation of the Hip. J. Bone and Joint Surg., XXI, 648, July 1939.

Ombrédanne, L., et Mathieu, P.: Traité de chirurgie orthopédique. Paris, Masson et Cie, 1937.

Putti, Vittorio: Early Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XI, 798, Oct. 1929.

Early Treatment of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XV, 16, Jan. 1933.

Anatomia della lussazione congenita dell'anca. Bologna, Licinio Capelli, 1935.

Ridlon, John: Congenital Dislocation of the Hip. Surg. Clin. Chicago, I, 271, 1917.

Lessons from My Experience with Congenital Dislocation at the Hips. J. Orthop. Surg., III, 365, Aug. 1921.

Scaglietti, O.: Indirizzi odierni nel trattamento della lussazione congenita dell'anca. Chir. d. Org. di Movimento, XXV, 308, 1940.

Schede, F.: Die Ergebnisse unserer Behandlung der angeborenen Hüftverrenkung. Ztschr. f. Orthop. LXXI, 3, 1940.

Severin, Erik: Contribution to the Knowledge of Congenital Dislocation of the Hip Joint. Late Results of Closed Reduction and Arthrographic Studies of Recent Cases. Acta Chir. Scandinavica, LXXXIV, Supplementum 63, 1941.

Steindler, Arthur; Kulowski, Jacob; and Freund, Ernest: Congenital Dislocation of the Hip. Statistical Analysis. J. Am. Med. Assn., CIV, 302, 1935.

Vogt, E. C.: Congenital or Infantile Dislocation of the Hips. Am. J. Roentgenol., XXXVII, 21, 1937.

Waldenström, Henning: *Quoted by* Severin.

Werner, Rudolf: Spontanheilung einer einseitigen sicher erbbedingten Hüftgelenksverrenkung und einer doppelseitigen. Ztschr. f. Orthop., LXX, 326, 1940.

BURSITIS IN THE REGION OF THE TIBIAL COLLATERAL LIGAMENT*

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ANATOMY

The anatomical facts relative to the tibial collateral ligament and its subjacent structures, particularly the bursae, have been described in two previous papers.[1, 2] In these articles, the following pertinent facts were demonstrated:

1. The tibial collateral ligament moves anteriorly with extension of the knee, and posteriorly with flexion.

2. The parallel fibers of this ligament, taut in extension, do not relax in flexion.

The locations of the bursae associated with this ligament were described in the second article.[2]

ETIOLOGY

Clinical bursitis in this region may be due to any one of the recognized causes of bursitis elsewhere, but apparently the most likely factors in this location are: compression or friction of the bursa between the tibial collateral ligament and the edge of the tibial tuberosity, which may be irregular or roughened by arthritis or old trauma; by direct contusion, with or without hemorrhage into the bursal cavity; unaccustomed frequent knee action, especially involving full flexion under muscle tension, such as steep-step or ladder climbing, squatting in limited space, "duck waddling" in squat position, bicycling, *et cetera*. So far, no case of bursitis has been seen in association with tearing of the medial meniscus or with synovitis, acute or chronic.

Age does not seem to be a controlling factor, as the youngest patient was ten years of age, and the oldest, sixty-two years; although all but three patients were in the twenty-to-forty age period.

HISTORY

Most of the patients in our small series gave a history of recurrent attacks of pain in the knee, following periods of repeated flexion of the knee under strain of weight-bearing or the twists of work done in a squatting position; several received direct contusions, one in football, one sliding down some steps, and another against a solid object; others knew of no specific causative factor.

EXAMINATION

Objective signs were not always present, but, when they were, visible and palpable enlargement of varying size was present beneath the tibial collateral ligament near the middle of the parallel fibers. The enlargement was always tender on pressure, and, when the ligament was tightened by hyperextension, abduction or outward twisting of the lower leg, and sometimes by full flexion, it was semifluctuant, as though fluid were under pressure. If no enlargement was present, all the other signs were, except swelling and semifluctuation.

Aspiration of bursal fluid is considered an important positive sign.

DIAGNOSIS

The only absolute proof of the diagnosis is excision of bursal tissue, followed by symptomatic relief. Unfortunately this procedure is not always clinically possible or proper; consequently other methods must be depended upon; the best of these is aspiration of bursal fluid with reasonably prompt relief of symptoms. In lieu of, or in conjunction

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with, either of these, an almost certain diagnosis may be made upon the history, the localization of swelling and tenderness, and pain when the tibial collateral ligament is tightened by hyperextension or abduction of the tibia, with relief on flexion or adduction. The area of tenderness is almost pointlike, and is usually located between the ligament and the tibial edge, although it may be over the base of the meniscus. In the latter case, it is much more limited in scope than is a torn meniscus, with which it is most likely to be confused. Since fracture of the tibia and a torn ligament are so much more severe, and since they are associated with acute trauma, confusion with them is unlikely. Fibrositis of the ligament or subjacent fascia, especially in the presence of a spur or exostosis on the tibia, might cause difficulty, as bursitis could occur then also. Roentgenograms of the area eliminate confusing elements of bone change and may show soft-tissue swelling or calcification.

TREATMENT

If possible, aspiration is done when localized tender swelling is observed or palpated beneath the tibial collateral ligament.

The area is infiltrated with several cubic centimeters of novocain, whether or not bursal fluid has been aspirated. If fluid has been obtained, the novocain is injected into the bursal cavity.

The knee is protected and motion is limited by actual rest and by the use of an elastic bandage or support, or, if necessary, by the use of something more rigid.

Diathermy or deep heat is given to the area.

The knee is returned to active use slowly and carefully, to avoid strain and repeated flexion of the joint.

If recurrence takes place, this treatment should be repeated at least until the surgeon is convinced that conservative measures are unavailing.

As a last resort, or if the enlargement is such as to be a constant mechanical hindrance to the free action of the tibial collateral ligament, operative exploration of the area is proper, with excision of the thickened or swollen tissue. If the diagnosis has been accurately determined, an enlarged sac may be located and dissected free in its entirety. If operation is carefully carried out, no damage need be done to the meniscus, synovial membrane, ligament, or associated vessels, nerve, *et cetera*. The bursa will be found to be entirely extra-articular.

CASE REPORTS

CASE 1. J. P., a male, aged thirty-nine years, had had recurrent attacks of pain in the right knee, without demonstrable signs, until December 1940, when he complained that for two weeks he had had pain in the medial aspect of the right knee, whenever he squatted or twisted the knee.

Examination revealed a small, tender, palpable swelling between the medial meniscus and the tibial collateral ligament; only hyperextension and external rotation caused pain in the affected area. Roentgenograms were negative.

Aspiration of two cubic centimeters of fluid was done. Two weeks later, 0.5 of a cubic centimeter was withdrawn and 0.25 of a cubic centimeter of monolate was injected into the site. There was almost complete relief of symptoms in a week, although a firm nodule could be felt.

In October 1941, he again complained of soreness which had lasted for two weeks; this was due to the considerable amount of squatting which was required in his work. Examination showed a larger and more tender swelling at the former site; it was firm and non-fluctuant. Full extension and full flexion caused pain on the medial side of the knee, and external rotation of the lower leg caused even more pain; internal rotation was painless. Roentgenograms were again negative, except for soft-tissue swelling.

The diagnosis was bursitis beneath the tibial collateral ligament of the right knee.

At operation a semifirm mass was found between the ligament and the medial meniscus. This was excised, without disturbing or injuring the ligament or meniscus. Before excision, the ligament could be seen sliding over the mass; the latter was apparently not attached to the meniscus. Pathological examination showed changes consistent with chronic bursitis. Recovery was uneventful, and the patient has had no recurrence.

CASE 2. R. B., a male, aged ten years, had been playing football two days previously. After being

tackled and fallen upon by a much larger boy, the patient had pain in his right knee. He had since been unable to straighten or bend the knee fully, because of pain on the medial side of the joint. There was some swelling in this area.

On examination, the patient could not extend the right knee beyond 15 degrees of flexion, because of pain beneath and just anterior to the tibial collateral ligament. A slight fullness in this area was apparent; there was local tenderness and a slight excess of fluid in the joint. Roentgenograms were negative except for a somewhat abnormally shaped patella.

The first diagnosis was torn medial meniscus and loose fragment in the knee, in spite of the fact that a torn meniscus is exceedingly unusual in children under fourteen or fifteen years of age. Four days later, when rest had made no change, the knee was explored, and the meniscus was found to be normal, as was the rest of the joint. Even under anaesthesia, full extension of the knee was impossible; therefore, the extra-articular area near the tibial collateral ligament was explored, and a blood clot within a bursal cavity was located and removed. As soon as the clot was removed, the knee could be extended fully. No return of symptoms has occurred.

The final diagnosis was hemorrhagic bursitis under the tibial collateral ligament.

CASE 3. F. H., a male, aged forty-nine years, had had, for the previous two to three years, a large swelling, 5 centimeters in diameter, beneath and anterior to the tibial collateral ligament. The same knee had ached for years previously. He had done a great deal of walking for twenty-five years.

Examination showed a mass, 7.5 centimeters in diameter, beneath the right tibial collateral ligament. It was tensely fluctuant, slightly tender, and extra-articular.

The diagnosis was bursitis beneath the right tibial collateral ligament.

The tumor was removed completely; this was followed by the elimination of symptoms, and complete recovery.

Later, a nodule, 1.5 centimeters in diameter, was noted posterior to the site of the previous mass and to the parallel fibers of the ligament. This was firm, as though calcified; it bulged the ligament and almost projected through the fibers. No pain or symptoms were present. Eight months after operation, the firm mass had softened and had decreased much in size.

CASE 4. W. N., a male, aged thirty-eight years, had been squatting fully and holding a heavy refrigerator door on the left knee, nine months previously. Pain and slight swelling had developed on the medial side of the knee. Seven days before being seen, while carrying a heavy machine, with his left leg twisted outward, the patient had had a sharp twinge of pain in the same area. Since then, he had had a small tender lump on the medial side of the joint.

On examination, the patient had a slight limp on the left, and slight thickening of the medial side of the left knee. The tibial collateral ligament was painful on motion, and tender over the center of the ligament where a lump, 7 millimeters in diameter was felt. The lump, located over the base of the meniscus, felt cystic, and was painful on tensing the tibial collateral ligament. It moved slightly with the ligament. Roentgenograms were negative, except for soft-tissue swelling corresponding to the palpable enlargement.

The diagnosis was bursitis beneath the tibial collateral ligament on the left.

On aspiration, 0.25 of a cubic centimeter of gelatinous bursal fluid was removed; the symptoms were promptly relieved. Within a month all signs and symptoms had disappeared, except for a very small thickened area.

A month later, a lump, 4 to 5 millimeters in size, was felt, but it was not tender, or painful on motion of the knee, which was normal.

Six months later, there was slightly more puffiness on the medial side of the knee, with a firm cystlike enlargement in the center, 1.25 by 2.5 centimeters in size; it was tender and caused pain, referred toward the patella.

The diagnosis was recurrence of bursitis.

In April 1944, at operation, a moderately firm mass, 6 millimeters in diameter, was removed. It was completely extra-articular, and was located between the base of the meniscus and the longitudinal fibers of the tibial collateral ligament. Diagnosis of bursitis was made on the report of the Pathology Department (Fig. 2). The patient returned to work in three weeks.

FIG. 1

Case 3. The appearance of a mildly enlarged bursa, slightly posterior to the site of a previous bursa which had been removed.

FIG. 2

Case 5. Roentgenogram of injected bursa.

CASE 5.† J. P., a male, aged sixteen years, had had a firm nodular swelling for some time on the medial side of the knee joint. Following contusion of the swelling, soreness had developed rather abruptly.

On examination, a very firm nodular mass, 2.5 centimeters in diameter, was felt beneath the tibial collateral ligament. It was moderately tender and could be moved somewhat. Motions of the knee caused discomfort in this area, and full extension and flexion were prevented by pain from pressure, caused by the tension of the ligament.

Roentgenograms, after injection of an opaque material, showed a large dense mass in the location of the bursa under the tibial collateral ligament.

The diagnosis was bursitis beneath the tibial collateral ligament.

The mass was excised. All symptoms disappeared, and recovery was prompt and complete.

CASE 6. S. S., a male, aged thirty-four years, had been having, for two months, attacks of pain on the medial side of the right knee, beginning about the time he had started bowling weekly. He had recently been doing much more work, especially squatting, climbing steps, sitting low frequently to fit shoes, *et cetera*. The pain was more severe after a long Saturday's work or after bowling, and seemed to be increasing.

On examination, some fullness was present in the area of the right tibial collateral ligament over the edge of the meniscus and tibia, with acute local tenderness and pain when the ligament was placed under tension in full extension, but not when the knee was flexed.

The diagnosis was bursitis beneath the tibial collateral ligament on the right.

A week of rest and heat lessened all symptoms and signs. A month later, he had a slight recurrence, which subsided in a few days.

Within another month, he had an acute recurrence of swelling and tenderness beneath the right tibial collateral ligament. Attempted aspiration failed to obtain fluid, but injection of novocain into the area gave relief for four days; the injection was then repeated with almost complete relief. A year later there was no sign of the former condition.

CASE 7. E. B., a male, aged thirty years, had injured the medial side of the left knee four weeks previously, when he had fallen down a steep flight of stairs. He had been off his feet for two weeks, and then had had diathermy.

On examination, a tender spot was found between the medial epicondyle and the condylar edge, anterior to the tibial collateral ligament. Pain, similar to that from digital pressure, was felt in this localized area, when the ligament moved forward in extension, or when the knee was in marked flexion. There was some enlargement in the anterolateral condylar region. The patient was unable to extend the knee fully, because of pain on the medial side.

The diagnosis was contusion of the bursa beneath the tibial collateral ligament.

† The authors are indebted to Lieutenant Colonel T. C. Thompson for this case.

Diathermy and contrast hot pad and cold compresses were used. One month later the patient was much improved; he had full extension and improved flexion.

CASE 8. R. B., a male, aged twenty-four years, had, six years previously, struck the medial side of the right knee on a hurdle in track. Pain and swelling in this area followed, but cleared up with rest. The patient has had several recurrences since, not always due to a blow. The latest recurrence, with swelling, had been a week or so before he was seen.

On examination, swelling was found under the tibial collateral ligament, and there was local tenderness. Extension was limited, apparently due to pain.

The diagnosis was bursitis beneath the tibial collateral ligament on the right.

Nine days later, when the condition was no better, the area was injected with novocain; relief was immediate and complete. Two days later, the patient was well and back at his regular work. A year later, the patient was shifted to other work which, required considerable squatting, lifting, and stair-climbing. Within a few weeks the right knee began to ache, and swelling on the medial side recurred, preventing full extension and causing continuous pain.

Examination revealed a tender swelling, 1.5 by 2.5 centimeters, under the right tibial collateral ligament. The patient was unable to extend the knee fully, because of increased pain due to pressure caused by the taut ligament. Roentgenograms of the knee were negative.

The diagnosis was recurrence of bursitis under the tibial collateral ligament. Excision has been recommended, and is to be done as soon as convenient.

CASE 9. J. J., a male, aged sixty-two years, had had a sudden pain in the medial side of the right knee eight days previously.

Examination revealed local tenderness and pain on knee motion; it was localized under the tibial collateral ligament.

The diagnosis was acute bursitis beneath the tibial collateral ligament on the right.

Rest and heat gave relief after two weeks.

CASE 10. A. G., a male, aged thirty years, had, two weeks previously, stooped a good deal, and had carried a considerable amount of material up and down steps for several days consecutively. This had required excessive and repeated knee-bending.

On examination, the inner side of the right knee was tender. The patient walked with a limp, and could not extend the knee fully because of acute soreness. No swelling was visible in the tender area.

The diagnosis was bursitis under the tibial collateral ligament.

After rest for a week and vacation, all symptoms cleared up.

SUMMARY AND CONCLUSIONS

A new clinical entity has been presented,—namely, bursitis beneath the tibial collateral ligament of the knee.

Ten cases have been reported, four of which have been definitely proved by operative excision of the enlarged bursa. From one patient, bursal fluid was removed by aspiration; later this patient was operated upon.

Several of the cases might have been diagnosed by some as fibrositis or fasciitis, but, to us, these terms indicate signs other than those listed here.

Novocain injection into the painful area has been used repeatedly, with completely beneficial results in some cases, especially in those with no palpable enlargement.

REFERENCES

1. BRANTIGAN, O. C., AND VOSHELL, A. F.: The Mechanics of the Ligaments and Menisci of the Knee Joint. J. Bone and Joint Surg., XXIII, 44, Jan. 1941.
2. BRANTIGAN, O. C., AND VOSHELL, A. F.: The Tibial Collateral Ligament: Its Function, Its Bursae, and Its Relation to the Medial Menisci. J. Bone and Joint Surg., XXV, 121, Jan. 1943.

DISCUSSION

DR. RALPH K. GHORMLEY, ROCHESTER, MINNESOTA: Some time ago Dr. Voshell, in the "Correspondence Club Letter", told about this condition, and asked for reports of additional cases. Shortly afterward, I encountered two cases which I wish to present now.

The first was that of a man, aged forty years, who had had a swelling on either side of the knee at the level of the upper end of the tibia, with some pain. We, who examined him, felt that there was a gelatinous body in the bursa and proposed excision. The ligament was reflected backward, and the knee joint was purposely opened to make sure that there was no injury to the meniscus. No injury was found. The bursa was excised, and was found to be filled with gelatinous material. The patient made satisfactory recovery.

In the second case, a woman of fifty years presented herself, because of an exquisitely tender spot on the knee. We suspected that a calcified bursa might be present, although, in the original roentgenogram, the appearance was much like that of an osteocartilaginous loose body. In order to establish a diagnosis, the spot was punctured with a needle, after injection of procaine, and a little milky material was aspirated. Three weeks later her symptoms were gradually subsiding; nearly seven months after she was first seen, her symptoms had been completely relieved, and the shadow of the calcified bursa had disappeared from the roentgenogram. The sequence of events is similar to what all surgeons have seen in cases of subdeltoid bursitis with calcification.

Dr. Robert B. Osgood, Boston, Massachusetts: Just for a moment may I speak of the experiences I have had with bursae of the knee joint, of the shoulder, and of the elbow. Next door to me is a man with a very wide experience in roentgenography. He asked me to try roentgenotherapy on some of these bursae. I have been amazed at the results obtained in three or four dozen cases. Then I had a bursa on my own foot. I had just about decided to have it dissected out, when Dr. Morrison suggested that I try roentgenotherapy. In a week's time, after two treatments, it was much better, and the calcium deposit had disappeared. I wish I were a roentgenologist to tell you the exact amount of screening and the units to use, but the relief is so complete and so permanent, and the disappearance of the calcium is so universal, that I think it is something we should consider very seriously. In my experience with patients treated by Dr. Morrison's technique, the relief has been almost completely successful.

Dr. E. B. Mumford, Indianapolis, Indiana: I have had four cases in which I made a diagnosis of bursitis; one patient was operated upon. The other three have been relieved by injections of novocain.

Colonel R. I. Harris, Toronto, Ontario, Canada: I would like to ask Dr. Voshell, whether or not he has ever seen a case of bursitis in relation to the external collateral ligament, similar to what he has described in connection with the medial collateral ligament.

Dr. Allen F. Voshell, Baltimore, Maryland (closing): I want to thank Dr. Ghormley and Dr. Osgood for their contributions to the subject, and I realize quite well that many of you have seen cases which would have been classified under the heading of bursitis, if bursal tissue had been expected at this site. Whether the structure is a true bursa or a ganglion is a question, raised by Dr. Phemister, and which will have to be studied further, but according to the pathologists the structure has been called a bursa. A suggestion by Dr. Freiberg, that perhaps some so-called cysts of the meniscus might be subligamentous bursitis, is certainly worthy of thought; it suggests a more careful examination at operation for either condition.

In reply to Colonel Harris's question, with reference to the presence of enlarged bursae on the lateral side of the knee, I would say that we had a case three weeks ago; it is unconfirmed as yet, but the well-known presence of bursae beneath the fibular collateral ligament does not make the condition so unexpected.

I hope you will all verify the findings in your own cases, so that some day we may be able to collect a really good series.

TREATMENT OF CONGENITAL TALIPES EQUINOVARUS WITH THE MODIFIED DENIS BROWNE SPLINT

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INTRODUCTION

The correction of the structural deformity in congenital talipes equinovarus has been successfully accomplished by the conventional forms of treatment, but the restoration of normal function has been a more difficult problem. It has long been recognized that failure to correct the internal torsion, muscle imbalance, and rigidity of the club foot results in considerable functional impairment, and favors early recurrence of the deformity. Any method which would seem to offer a solution to these problems deserves careful consideration. Recent observations on the use of the modified Denis Browne splint have indicated that it has done much to restore normal function as well as normal appearance to the foot with talipes equinovarus.

The use of metal splints connected by a cross bar in the treatment of club-foot was first advocated by Denis Browne [2,4,5] in order to correct the element of internal torsion in the deformity. He proposed that the position of either foot in respect to the sagittal plane of the body could be controlled by strapping the feet to the splints and rotating the latter on a cross bar.[2,3] It was soon observed that not only was the internal torsion corrected, but the forceful and persistent kicking permitted by this apparatus provided constant manipulation of the feet and an opportunity for the development of normal musculature. Thus was obtained a foot which was very flexible, had normal muscle balance, and was maintained in the normal plane of external rotation.

Curiously enough, the splint was used only as an adjunct in treatment, since the primary correction of the structural deformity of the foot was accomplished by forceful manipulations. Browne described these as "violent manipulations", and recommended forcing the foot into extreme calcaneovalgus until the dorsum of the fifth toe touched the tibia.[6,7] This manipulation was followed by considerable reaction, which presented a problem, as is evidenced by the fact that Harry advised the use of casts after the manipulation until the reaction had subsided. He then applied the splints and used them as retentive apparatus for maintaining correction, while obtaining external rotation.

Although Brockman and probably others in Britain have used the splint as a means of obtaining correction, as well as of maintaining it, it has been largely through the work of Thomson of Toronto that the method has become popular in this country. In his excellent paper appearing in *The Journal* in April 1942, he stressed the simplicity and effectiveness of the treatment which used a modified Denis Browne splint as the sole corrective force. Excellent results were obtained by merely strapping the infant's feet to the splint,

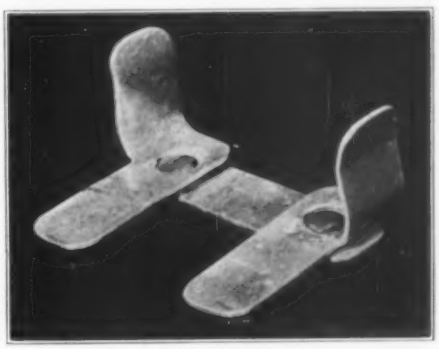

FIG. 1

One of the splints used by Denis Browne.

Before this splint is applied, the plates are removed from the bar. An adhesive felt wedge is placed beneath the lateral aspect of the forefoot, and the foot is strapped to the sole plate. Finally, the flange is strapped against the lateral aspect of the lower leg to evert the foot. The plates are then bolted to the bar in a position of external rotation.

and relying upon the infant's incessant kicking to correct the deformity. This method was used with similar success in sixteen cases by Samson of Montreal. The avoidance of manipulation with its complications seemed to be a definite step forward in the treatment of club-foot.

The use of the modified Denis Browne splint was started at The Children's Hospital in December 1941, and during the next two years over eighty cases of various types of talipes were treated. The adaptability of this splint to all forms of talipes has been gratifying, but its greatest advantage has been in the treatment of the uncomplicated congenital talipes equinovarus (fifty-three cases). Although the mild and moderate cases were handled well by Thomson's technique, particularly by those skilled in its use, we had to modify it to get more adequate correction of the severe deformity by accelerating the correction in the early stage. Changes were made to reduce the incidence of dermatitis and pressure sores, to get more adequate fixation of the foot to the splint, and to protect the normal foot; and finally a means was devised of maintaining correction, once it had been obtained. While these changes have been directed toward increasing the effectiveness of the method, the ultimate goal has been to standardize it so that new personnel can rapidly become adept in its use. The manner in which these problems have been approached can be appreciated best by a presentation of the technique.

METHOD OF TREATMENT

Apparatus

Consideration should first be directed toward the apparatus. Except for slight modification, it is quite similar to that described by Thomson, and others.[11,12] The plates are made in three stock sizes, the two smaller of which fit all feet up to nine months of age; for children over this age there is a large size with a steel ribbon attached to the under surface for reinforcement. The cross bars likewise are made in several stock lengths from seven to twelve inches (Fig. 2).

The shape of the plates we have used differs slightly from the conventional pattern.

FIG. 2

The splint as modified.

Showing the three sizes of plates (smallest, 4 by 1¾ inches; largest, 6 by 2¼ inches), and two of the several lengths of bar (7 and 8½ inches). The ring in the smaller bar is for suspension (Figs. 10-A and 10-B). Note the triangular shape to the plate with its narrow heel and straight medial border.

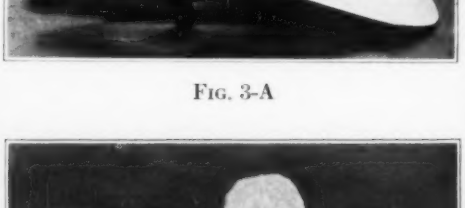

FIG. 3-A

FIG. 3-B

The plate.

Fig. 3-A: Lateral aspect. The plate has been arched and the edge of the flange flared outward.

Fig. 3-B: Medial aspect. Sponge-rubber padding has been applied.

As indicated in Figure 2, each plate is roughly triangular. This shape conforms well to the contour of an infant's foot. Thus, the adhesive strapping can be made to fit snugly about the heel. The medial border of the plate has been cut straight, instead of inflared, so as to allow strapping of the forefoot in a position to correct the adduction. The flange is situated well back on the lateral side, so that the heel can be strapped against it, thus controlling inversion; yet not placed back far enough to interfere with the strapping which holds the heel down to the plate. The flange is cut low enough so that it will not limit ankle motion (Fig. 3-A).

Before the plates are ready to be applied, it is necessary to arch them in the midtarsal region, as shown in Figure 3-B. This step is indicated in early cases in order to get the plate to fit the foot; in the later stages it is still desirable, because it maintains the longitudinal arch. The edge around the flange is flared outward, so that it will not dig into the foot even when the latter is tipped into eversion. Without this outflare, pressure areas may appear beneath the external malleolus. After the plate has been shaped, it is padded, preferably with sponge rubber, three-eighths of an inch thick, which stays resilient and keeps clean longer than do other substances,—such as felt (Fig. 3-B).

Strapping

In strapping the plate to the foot, several things should be kept in mind. First of all, the phrase "strapping the plate to the foot" should be emphasized. The plate must fit the foot in size and contour, and, in the early stages of treatment, it must be applied in the position of the deformity. If one attempts to get too much correction when first applying the splints, either the strapping gives way or pressure sores develop. Both of these misfortunes are to be avoided. If the strapping becomes loose, proper correction will be interfered with. This is particularly true of the heel, because if it pulls out and the forefoot remains attached to the plate, a rocker type of deformity can develop within a short time. On the other hand, the strapping must not be so tight as to block circulation or to cause pressure areas, which are especially disconcerting because they delay correction just at a time when it should be pushed most rapidly. If, however, the splints are properly applied, few such complications should be encountered.

The arrangement of the strapping is designed not only to hold the plate securely to the foot, but also to gain immediate correction of some of the deformity. Before the adhesive tape is applied, the feet are cleaned and painted with compound tincture of benzoin. Strips of tape, one inch and one-half of an inch wide, are generally used, although narrower pieces may be preferred in small infants (Fig. 4). The first and second straps are applied in an effort to correct the forefoot adduction. The principle and technique of applying these straps are shown in Figures 5-A, 5-B, 6-A, and 6-B. A piece of thin felt padding is placed under the second strap as it crosses the dorsum of the foot, since this is the site to which is applied much of the pressure to hold the heel

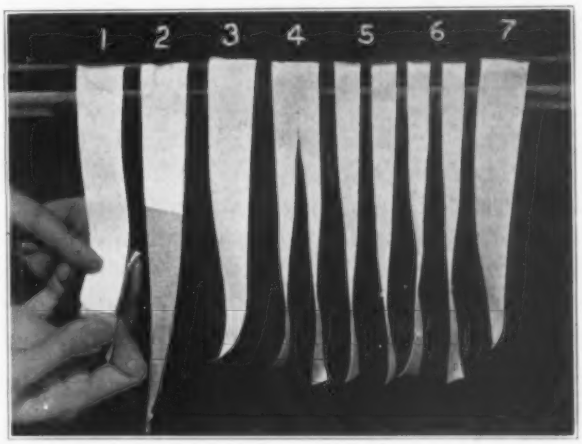

FIG. 4

The adhesive tape straps.

Straps *1* and *2*, which control the forefoot adduction, are each made from two pieces of tape of unequal length, and overlapped face to face for a distance of approximately two inches. Straps *3*, *4*, *5*, and *6* are concerned chiefly with the position of the heel. Strap *4* is made by splitting a piece of tape one inch wide so as to form a swallow tail. Straps *5* and *6* comprise a pair of strips each one-half of an inch wide. Strap *7* represents the one or more strips necessary to secure the forefoot or to bind in the ends of the other strips.

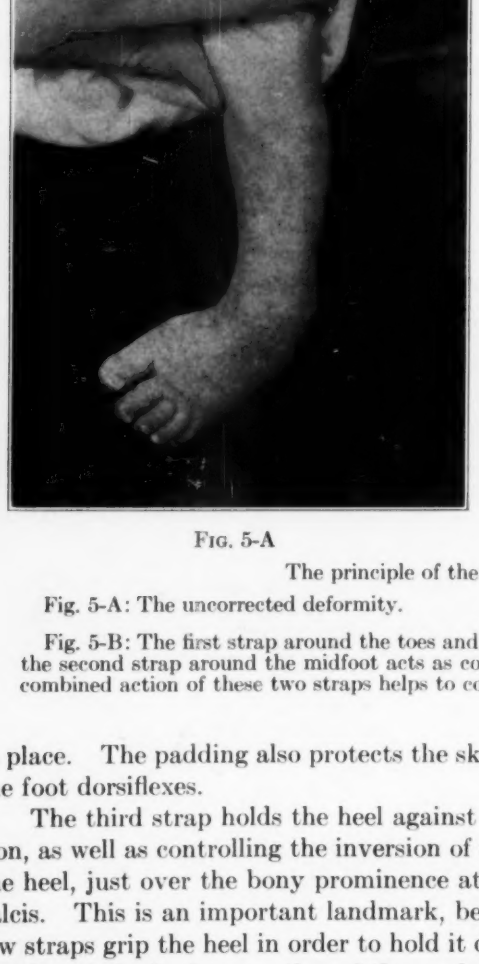

FIG. 5-A

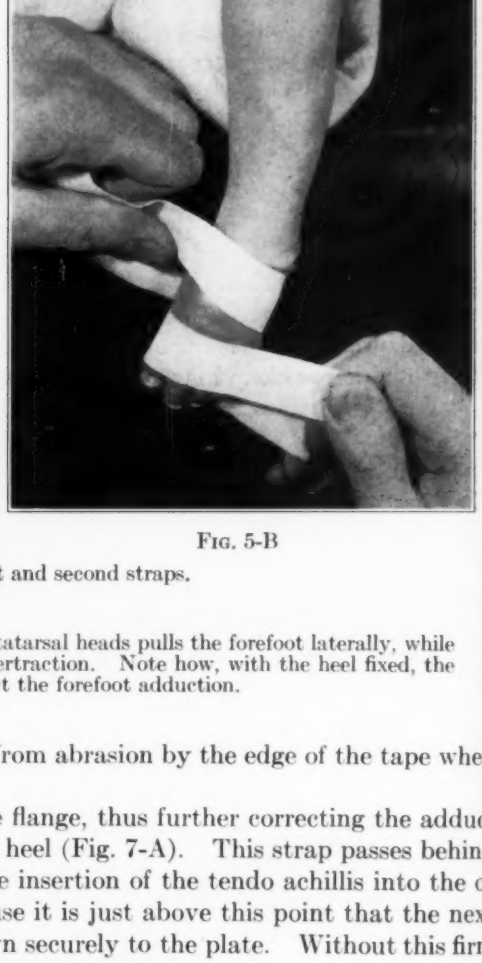

FIG. 5-B

The principle of the first and second straps.

Fig. 5-A: The uncorrected deformity.

Fig. 5-B: The first strap around the toes and metatarsal heads pulls the forefoot laterally, while the second strap around the midfoot acts as countertraction. Note how, with the heel fixed, the combined action of these two straps helps to correct the forefoot adduction.

in place. The padding also protects the skin from abrasion by the edge of the tape when the foot dorsiflexes.

The third strap holds the heel against the flange, thus further correcting the adduction, as well as controlling the inversion of the heel (Fig. 7-A). This strap passes behind the heel, just over the bony prominence at the insertion of the tendo achillis into the os calcis. This is an important landmark, because it is just above this point that the next few straps grip the heel in order to hold it down securely to the plate. Without this firm fixation of the heel, correction of the equinus would be difficult.

The fourth strap is made by splitting a piece of one-inch tape so as to make two long swallow tails (See Figures 4 and 7-B). This strap is so applied over the back of the lower leg and foot, that the notch straddles the posterior tip of the os calcis. The tails are then pulled down snugly, and anchored around the plate and across the instep. The grip of this strap on the heel is strengthened by a set of crisscross straps of one-half-inch tape, which, starting on opposite edges of the plate, pass upward and backward to cross each other in the hollow just above the insertion of the tendo achillis (Fig. 8-A); the upper ends of these straps are secured by encircling the leg. A second set of crisscross straps are carried, one from each side, across the instep, diagonally downward and backward, to fasten around the heel of the plate, thus preventing the heel from slipping forward out of the strapping (Fig. 8-B).

A few additional straps are then placed to bind in the ends. Care should be taken that the strapping across the instep is not high enough to limit dorsiflexion. It should also be noted that the toes as well as the metatarsals are firmly fixed to the splint in a position of correction (Fig. 9-A).

When the strapping has been completed, and circulation in the toes is deemed satisfactory, the feet are allowed to take the position they normally assume.

FIG. 6-A

FIG. 6-B

Application of the first and second straps.
(In these views the non-adhesive surface of each strip of tape has been dyed black.)

Fig. 6-A: The adhesive surface of the short tails of the first and second straps has been affixed to the under surface of the plate, and the free end of each strap has been carried around the lateral and the medial border of the plate, respectively, so that the overlapped portion of each strap comes to lie in a position between the sponge-rubber padding and the sole of the foot.

Fig. 6-B: With the foot held in a corrected position against the plate, the first strap is brought up around the medial side of the big toe and first metatarsal head, and is then carried across the dorsum of the forefoot to the lateral side of the plate. The second strap is brought up from the lateral side of the foot, across the dorsum of the mid-foot, and then downward and backward to anchor onto the posterior portion of the under surface of the plate. Underlying this strap, as it crosses the instep, is a piece of thin felt padding, the white edges of which appear in the photograph. Often one or two additional straps are necessary to anchor the forefoot securely to the plate.

Starting a New Case

In a new case where the correction is just being started, the position normally assumed is usually one of internal rotation and inversion. If so, the cross bar is bent in the shape of an inverted V to conform to the inversion, and is then applied to the plates with the latter somewhat internally rotated (Fig. 9-A). Starting the treatment with the feet in this position has several advantages. Although during the first week little active correction is accomplished, the flexibility of the foot is greatly improved. By starting the correction slowly, the incidence of dermatitis and pressure areas can be reduced to almost nothing. Too strenuous correction results in a fretful child, which often discourages the parents about the treatment. Actually, if the child is given an opportunity to become adapted to the splints, he is usually quite contented.

In order to encourage the infant to kick, the cross bar is suspended by an elastic from a cradle or stick across the crib (Figs. 10-A and 10-B). This also prevents the feet from remaining constantly in equinus, as they tend to do if not suspended. Thus the correction of the equinus is begun immediately, without waiting until the splints are externally rotated. We feel that this early correction of the equinus is of considerable importance. In addition, suspension of the apparatus favors adequate venous return of blood from the feet; it also reduces the wear on the bed clothes. This suspension is usually continued until the plates have been externally rotated to a considerable degree.

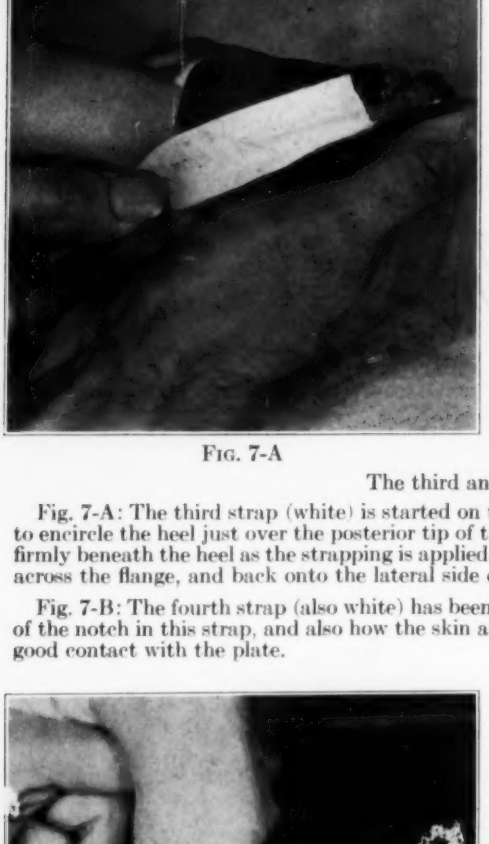

FIG. 7-A

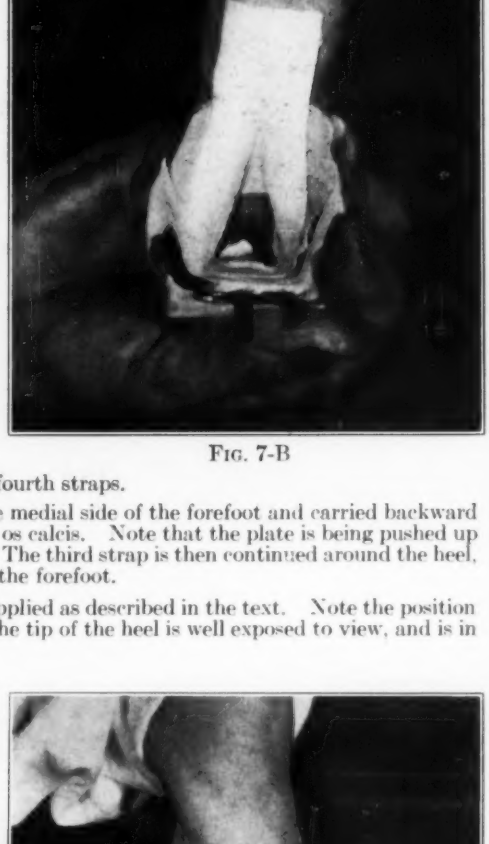

FIG. 7-B

The third and fourth straps.

Fig. 7-A: The third strap (white) is started on the medial side of the forefoot and carried backward to encircle the heel just over the posterior tip of the os calcis. Note that the plate is being pushed up firmly beneath the heel as the strapping is applied. The third strap is then continued around the heel, across the flange, and back onto the lateral side of the forefoot.

Fig. 7-B: The fourth strap (also white) has been applied as described in the text. Note the position of the notch in this strap, and also how the skin at the tip of the heel is well exposed to view, and is in good contact with the plate.

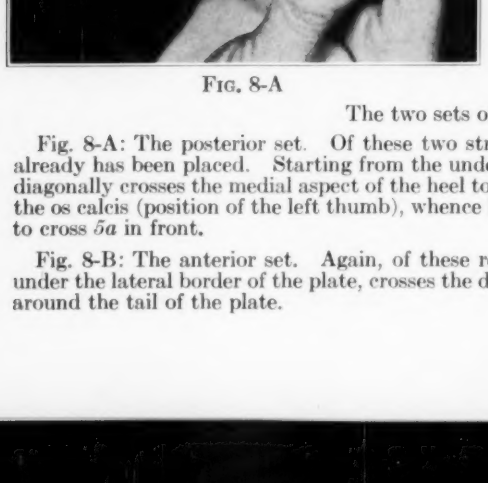

FIG. 8-A

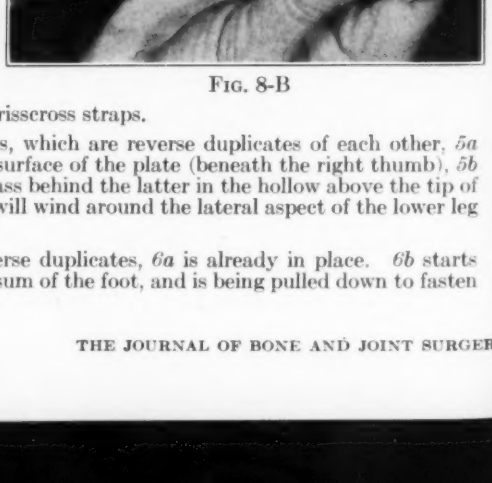

FIG. 8-B

The two sets of crisscross straps.

Fig. 8-A: The posterior set. Of these two straps, which are reverse duplicates of each other, *5a* already has been placed. Starting from the under surface of the plate (beneath the right thumb), *5b* diagonally crosses the medial aspect of the heel to pass behind the latter in the hollow above the tip of the os calcis (position of the left thumb), whence it will wind around the lateral aspect of the lower leg to cross *5a* in front.

Fig. 8-B: The anterior set. Again, of these reverse duplicates, *6a* is already in place. *6b* starts under the lateral border of the plate, crosses the dorsum of the foot, and is being pulled down to fasten around the tail of the plate.

FIG. 9-A

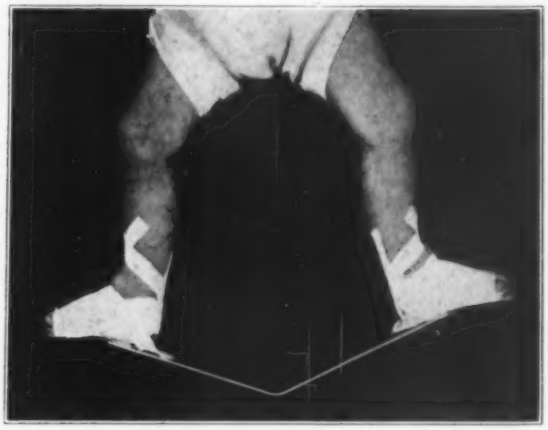

FIG. 9-B

Application of the bar.

Fig. 9-A: This view shows the finished strapping and the approximate position for the feet when first applying the splint. The reverse V in the bar and internal rotation of the plates guard against too vigorous correction in the early stages.

Fig. 9-B: In the later stages of correction, the plates are externally rotated 90 degrees. The V in the bar increases the dorsiflexion, while the bend in the plates protects the longitudinal arch. The length of the bar is such as to exert minimal torsion on the knees.

Instructions to Parents

It is surprising how readily most parents have comprehended the problems related to the home care of their infant while in the apparatus. The mother is shown how the bar is attached to the plates, how suspension is accomplished, and how the plates can be removed from the feet by cutting the adhesive. For about half an hour, twice a day, the splints are removed from the bar in order to rest the feet; or, as an alternate to this, the feet can be internally rotated at regular intervals. These rest periods have contributed considerably toward reducing the incidence of pressure areas.

If the child should become fretful, or should show any evidence of circulatory embarrassment, the parents are instructed to remove the splints from the bar until improvement occurs. If the circulation fails to improve, the feet are removed from the plates at once, and the child is brought to the Clinic the next day. This has rarely been necessary.

Of equal importance to the dangers of tight strapping are those of loose strapping. If the strapping about the heel becomes loose, the heel will pull up from the splint, and in the course of a few days a rocker deformity may occur. To prevent this, the position of the heel is checked regularly by the mother; and, if slipping has occurred, the foot is immediately removed from the plate. This check on the position of the heel is possible because the arrangement of the strapping (Fig. 7-B) leaves the tip of the heel exposed to full view, a decided advantage over the cast method, where one can never be sure of the exact position of the heel.

On the morning of the Clinic visit, the adhesive strapping is removed by the mother at home. The feet are cleaned with some solvent such as benzene, then washed, and painted with compound tincture of benzoin. This preparation of the skin by the mother is designed not only to reduce the time required for treating each patient in the Clinic, but also to give the skin an opportunity to dry out completely before the reapplication of tape. Before inaugurating this plan, we had considerable difficulty with dermatitis, so much in some cases that we had to discontinue strappings for several weeks. However, since the mothers have been preparing the skin, we have been troubled very little with this complication. Occasionally it may be necessary to take the feet out of the splint the night before or even two days before coming to the Clinic. This may result in some loss of correction, but the benefits of an intact skin are far more significant. It ought also to be said

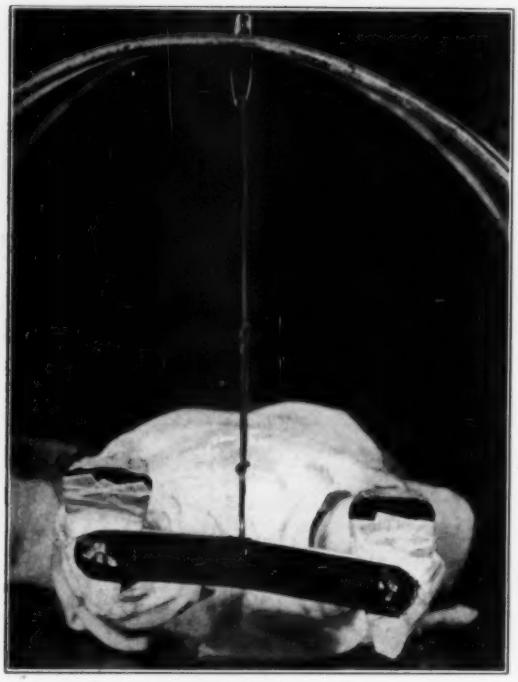

FIG. 10-A

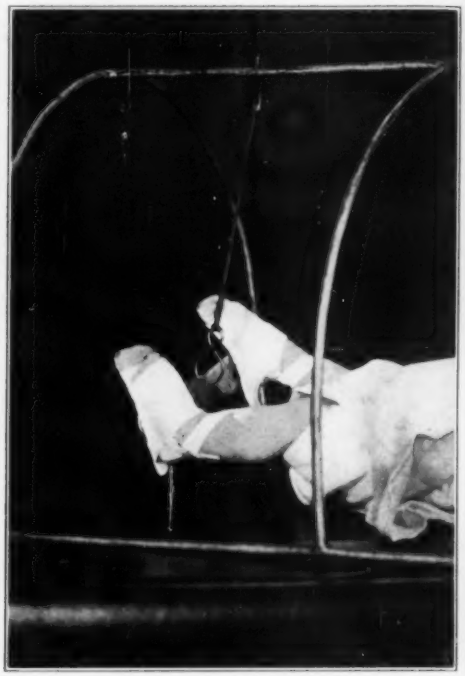

FIG. 10-B

Elastic suspension of the splint.

In these illustrations, rubber bands serve to suspend the ring in the bar from a cradle overhead. Not only does this suspension encourage kicking, but note also how much correction of the equinus has already been obtained.

that the padding on the splints should be equally dry and clean. Fortunately we have not encountered true sensitivity to the tincture of benzoin or to the adhesive tape.

Progress in Correction

Once the correction has been started, the progress is usually quite satisfactory. For the first week or two, the strapping is changed every four or five days. Thereafter, it is changed once a week until time for intermittent strapping. It is our feeling that correction should be as rapid as possible, because we believe that the sooner the deformity has been corrected and function restored, the better will be the result. Therefore, the plates are externally rotated on the bar as fast as the rigidity of the foot permits. The cross bar is straightened from its inverted V shortly after the first week; and then, when the plates have been externally rotated to about 90 degrees, a bend in the reverse direction is placed at the center of the bar so as to increase the dorsiflexion of the feet (Fig. 9-B). In selecting the proper length of bar, it is often necessary to try on several before finding one which, with the feet held in the desired position, will put the least stress on the knees in the various positions of flexion and extension. Although strain on the knees is a theoretical objection to the Denis Browne splint, we have found only one case in which the splint produced ligamentous relaxation at the knees.

Preservation of the longitudinal arch, however, has proved to be a more serious problem. In the midst of efforts to correct the varus and bring the heel down out of equinus, there is a natural tendency to destroy the longitudinal arch. This, to our minds, is the first stage of rocker deformity. We make every effort to preserve the longitudinal arch, not only because it gives a foot of more normal appearance and function, but also because we believe that the integrity of the structures supporting the longitudinal arch is essential for full correction of the equinus. If these structures are stretched out, then adequate

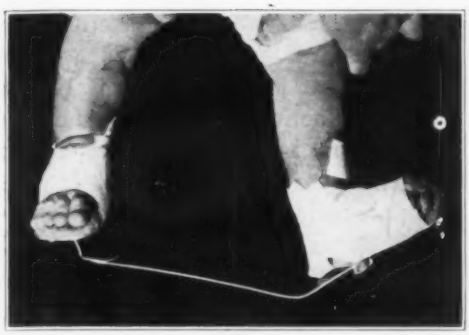

FIG. 11-A

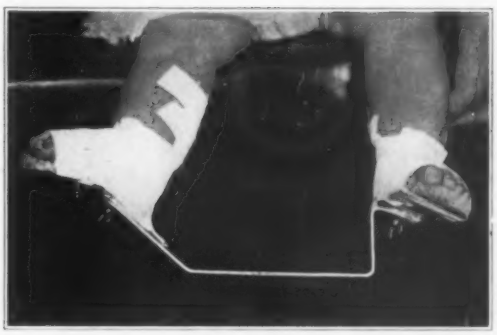

FIG. 11-B

For unilateral deformity.

Fig. 11-A: Method of Jergesen, in which a U-shaped extension is inserted between the bar and the plate strapped to the normal foot. (*Reproduced from The Journal of Bone and Joint Surgery, XXV, 186, Jan. 1943.*)

Fig. 11-B: Method of Zecchino, in which the cross bar itself is shaped to prevent valgus of the normal foot.

dorsiflexion of the hindfoot becomes difficult, if not impossible. Thus, as the plates are tipped up into more and more dorsiflexion, it becomes increasingly important to keep the plates well arched in the mid-tarsal region and to make certain that the heels stay securely strapped to the plates (Fig. 9-B). The importance of the strapping just above the tip of the os calcis has already been emphasized.

Treatment of Unilateral Deformity

The foregoing discussion has concerned itself primarily with bilateral talipes equinovarus. If the case presents unilateral deformity, or if the deformity of one foot is more resistant than that of the other, certain alterations are necessary in the bar and in its attachment to the plates. Early in our experience with unilateral cases, it was noted that, even if the normal foot were kept in neutral rotation (as suggested by Thomson and Samson), it was being continually pushed into valgus by the action of the other foot. The child invariably kept the normal leg flexed and the leg with the club foot extended, probably because this position diminished the corrective force on the deformed side; but it also increased the valgus on the normal side.

To obviate this difficulty, an extension was put beneath the normal foot, thereby improving the leverage on the abnormal foot; and, at the same time, the plate supporting the normal foot was tilted so that, regardless of the relative position of the feet, the normal foot was always either inverted or in neutral position, never in eversion. The illustrations show two methods of accomplishing this purpose (Figs. 11-A and 11-B). One of these has already been described by Jergesen. Its advantage lies in the fact that the parts are interchangeable. The second method appears simpler, in that it requires only the shaping of a single bar. Note that the V in the bar to increase dorsiflexion comes well toward the abnormal side. A simpler type of strapping is usually sufficient to hold the normal foot to the plate. The latter should of course be bent so as to preserve the longitudinal arch.

CRITERIA FOR CORRECTION

The problem of how long to continue the use of the splint is of great importance. The fact that good flexibility and a normal-appearing contour to the foot are acquired so early in the course of treatment often misleads one into believing that correction has been obtained, long before that point has really been reached. Actually, the degree of passive correction may not be as good as casual inspection of the foot would seem to indicate. An example of this is shown in Figures 12-A, 12-B, and 12-C, where, although the external contour of the right foot indicates dorsiflexion of at least 30 degrees, a lateral roentgeno-

gram of this foot shows that much of this dorsiflexion has taken place in the mid-tarsal region, and that the hindfoot equinus is still uncorrected. Even after good passive correction has been obtained, it is still necessary for adaptive changes in the skeletal structures and restoration of muscle balance to take place before functional correction is effected. Once this has been accomplished, the foot will tend to stay in a corrected position even when out of the apparatus for some time. Although a severe deformity or delayed treatment in some cases may prevent the attainment of ideal correction, more often the failure is due to discontinuing the splint before full functional, as well as structural, correction has been obtained.

For these reasons, we have set up arbitrary standards of minimal correction to be obtained before the use of the splint is discontinued. The foot should be capable of passive dorsiflexion of at least 30 degrees at the ankle joint, and the foot should maintain itself in a slight degree of external rotation when at rest. Although careful examination of the foot will usually reveal the status of the passive correction, roentgenographic examination, particularly a lateral view in maximum dorsiflexion, serves as an accurate and permanent record (Figs. 12-B and 12-C). In older children, a lateral roentgenogram of the foot while bearing weight serves much the same purpose. The index to the degree of functional correction is the behavior of the foot when out of the apparatus. Unless the foot is well corrected, recurrence of the condition is the rule, even in the minor deformities. In general, at least four or five months of treatment are required before full correction is obtained, and some of the more severe cases require a longer period. If either the family or the doctor should become impatient with the slow progress during the later stages of treatment, it is well to remember that adaptive bone changes and restitution of muscle balance are slow processes. It is interesting that, in many of the unilateral cases, although

FIG. 12-A

Fig. 12-A: Bilateral deformity after partial correction. Even the right foot appears to have fair dorsiflexion.

Figs. 12-B and 12-C: Lateral roentgenograms of the same feet in maximum dorsiflexion. On the left side, fairly good correction has been obtained. On the right, however, the roentgenogram shows that the hindfoot is still in equinus, and that the apparent dorsiflexion is due partly to increased soft tissue beneath the os calcis, and also to dorsiflexion of the forefoot through the mid-tarsal joints, thus producing a rocker deformity. These views illustrate the value of the roentgenographic examination.

FIG. 12-B

FIG. 12-C

the use of the splint has greatly improved the musculature, there is still measurable atrophy of the involved leg as compared to the normal.

MAINTENANCE OF CORRECTION

After full correction has been obtained, there arises the problem of maintaining it until the child begins to bear weight. It is during this period that much of the correction is lost, and recurrence of the deformity is inevitable, unless precautions are taken to prevent it. For this purpose we tried the use of shoes attached to a splint, as described by Thomson. The use of this apparatus as the sole method of maintaining correction proved unsatisfactory, because the shoes of standard sizes were not made small enough to grip the infant's foot securely. Not only did the foot turn in the shoe, thus permitting recurrence of the varus; but the heel invariably pulled up in the shoe, thereby allowing the equinus to recur. The conventional casts were found even more unsatisfactory.

Therefore, we returned to the principle of Denis Browne, that is,—using the splint as the agent for maintaining correction. With the foot strapped securely to the splint, one could rest assured that the proper correction was being maintained. It has proved possible, however, to maintain this correction by using the splint only intermittently. Whereas, during the period of correction it is necessary to restrap the feet about every week; once the correction has been obtained, it is possible to have the parents remove the splint about seven to ten days after its application, and then return for restrapping in two or three weeks. If the correction is being satisfactorily maintained, the period out of the splint can be gradually increased.

Although, in the milder cases, the use of intermittent strapping alone may be adequate to maintain correction, in the moderate or severe deformities, it has seemed advisable to include some method of maintaining correction during the periods that the splint is off. The mother is, therefore, instructed in manipulations to be done several times a day, and, meanwhile, the correction is maintained at night and for periods throughout the day by some sort of removable apparatus. In the smaller infants, this is usually a short posterior molded plaster splint, which is made with the foot in considerable correction and is held in place by an ace bandage. In the older children, we have found the use of bivalved plaster casts most effective. Occasionally, when the deformity has been fully corrected, we have used the shoes attached to a splint. They are easy to apply, and serve very well to hold the foot in external rotation. Once the child begins to walk, the outer border of the shoe is wedged; and usually the shoes are worn reversed upon the feet, so as to maintain correction of the adduction. Eventually the feet become large enough to fit securely into club-foot shoes of the standard sizes.

RESULTS

The results obtained by this method of treatment of talipes equinovarus have been very gratifying. Although it is too recent to give any final evaluation of the results, it is possible to get a perspective of what can be gained with the initial correction. In this series of fifty-three cases, we have excluded those cases representing positional deformities, internal tibial torsion, or simple varus without the element of equinus, so that we have classified only four cases as mild. Of the other forty-nine cases, thirty-two were moderate and seventeen were severe. The distribution was the same as in other series. There were thirty-six boys and seventeen girls. In thirty-three cases, the deformity was bilateral; and in twenty, unilateral.

Of these fifty-three cases, six are still undergoing correction, and one died of intercurrent disease; thus, forty-six may be appraised. In evaluating the results, we have used the following standards: An *excellent* foot is one which is essentially normal,—that is, maintained in external rotation with full range of dorsiflexion and eversion. A *good* result is a foot which has no structural deformity, but presents some limitation of motion as

compared to the normal. A *fair* foot is one in which a mild deformity of one of the elements persists, but does not cause any appreciable disturbance in gait. Of these forty-six cases, the results were excellent in eleven, good in twenty-nine, and fair in six. In this latter group of cases, the possibility of recurrence has been appreciated. The real problem of recurrence has yet to be faced, since none of these cases has been followed more than two years. At present our efforts are directed toward obtaining more adequate correction, in the hope that the tendency to recurrence will be minimized.

The reasons for not obtaining excellent results in all cases are several. In some instances, particularly at first, our technique was at fault, so that pressure areas or rocker deformities interfered with good correction. In other instances, the use of the splint was discontinued prematurely. Certain cases, however, presented problems beyond our control. There were families who failed to return regularly for treatment, and there were rare instances in which the original deformity was unusually severe. More important, however, was the group of cases in which treatment was not started until late,—that is, when the child was six months of age or older. The correction obtained was better than could have been accomplished by other methods, but it fell far short of the results obtained in those cases in which treatment was started early. In order to ensure full correction, we believe that treatment should be started in the first week of life; and then should be pushed rapidly through the initial stages, because it is at this age that the structures of the foot lend themselves most readily to molding.

In older children, the deformity is more rigid and hence treatment is slower and correction more difficult. In general, the treatment of children over one year of age with the modified Denis Browne splint alone is not satisfactory. Great difficulty is encountered in keeping the apparatus intact, and in keeping the feet strapped securely to the plates. Furthermore, the resistance of the deformity in these older infants is much more marked. Consequently, it would seem advisable in these late cases to use, along with the splint, some other method for obtaining correction. This might be accomplished by forceful manipulations under anaesthesia, followed by maintenance of the correction with the splint, as in the original Denis Browne method; or in other instances, when complete correction has not been obtained by the splint alone, some sort of operative procedure,—such as lengthening of the heel cord, capsulotomy, or transplantation of tendon might be indicated. However it may be accomplished, full correction must be obtained, if recurrence of the deformity is to be prevented.

SUMMARY

1. During the treatment of fifty-three cases of uncomplicated congenital talipes equinovarus with the modified Denis Browne splint, several refinements in technique have been evolved to meet various problems,—such as pressure sores, dermatitis, incomplete correction, persistent equinus, loss of longitudinal arch, and unilateral deformity. These refinements are described.

2. Success of this method depends upon the accuracy with which the foot is fixed to the splint. If properly applied, the splints will allow correction of the varus, and yet will maintain the longitudinal arch while obtaining full correction of the equinus.

3. Recurrence of the deformity is a constant threat, but this tendency is minimized by complete correction early and then by continued use of the splint intermittently, at least until the child begins to walk.

4. The final evaluation of any method of treatment for club-foot will have to be deferred until the first group can be followed throughout the growth period. The results in this series of fifty-three cases do indicate, however, that this is an excellent method with which to obtain initial correction,—that is, a foot with normal appearance and function.

NOTE: The authors wish to express their appreciation to Mr. F. R. Harding for his assistance in making the photographs for the illustrations.

REFERENCES

1. Brockman, E. P.: Modern Methods of Treatment of Club-Foot. British Med. J., II, 572, 1937.
2. Browne, Denis: Congenital Malformations. Practitioner, CXXXI, 20, 1933.
3. Browne, Denis: Talipes Equino-Varus. Lancet, II, 969, 1934.
4. Browne, Denis: Talipes Equino-Varus. Practitioner, CXXXIV, 525, 1935.
5. Browne, Denis: Congenital Deformities of Mechanical Origin. Proc. Royal Soc. Med., XXIX, 1409, 1936.
6. Browne, Denis: Modern Methods of Treatment of Club-Foot. British Med. J., II, 570, 1937.
7. Browne, Denis: Talipes Equino Varus. Postgrad. Med. J., XIII, 349, 1937.
8. Browne, Denis: Congenital Abnormalities of the Extremities. Practitioner, CXLII, 270, 1939.
9. Harry, N. M.: Denis Browne Splints in the Treatment of Talipes Equino-Varus. Australian and New Zealand J. Surg., X, 117, 1940.
10. Jergesen, F. H.: The Treatment of Unilateral Congenital Talipes Equinovarus with the Denis Browne Splint. J. Bone and Joint Surg., XXV, 185, Jan. 1943.
11. Samson, A.: Traitement du pied bot congénital; procédé de Stuart A. Thomson. Ann. Méd.-Chir. de L'Hôp. St. Justine, Montréal, IV, 91, 1943.
12. Thomson, S. A.: Treatment of Congenital Talipes Equinovarus with a Modification of the Denis Browne Method and Splint. J. Bone and Joint Surg., XXIV, 291, Apr. 1942.
13. Zecchino, Vincent: Personal communication.

THE USE OF ALUMINUM ACETATE IN THE TREATMENT OF MALACIC DISEASES OF BONE*

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Many of us have for years tried to improve the condition of patients who had various sorts of malacic disease of bone, by means of medicines calculated to increase the amount of calcification in the regions of decreased density in bone. Most of these have met with either only moderate success or failure. It is true that in some of these conditions an apparent subjective improvement may take place on diets rich in vitamin D and calcium; but, as a rule, no objective improvement may be noted on comparison of roentgenograms taken before and after the treatment.[1]

Any method whereby one could with certainty see roentgenographic evidence of improvement in recalcification would be a welcome addition to our available methods of therapy in many types of bone disease.

The attention of the writers was attracted to an article by Helfet in which it was apparent, from a study of the roentgenographic reproductions illustrating the article, that some recalcification of bone had taken place, evidently due to the therapy described in his article.

In this study Helfet suggested "that parathormone exerts its primary effect on the phosphorus metabolism". To this end Helfet has elaborated a hypothesis as follows:

"1. That parathormone controls the blood-inorganic-phosphate level.

"2. That it prevents this level from rising to a degree which would upset any metabolic process in which the phosphates are concerned.

"3. That, conversely, an accumulation of phosphate in the blood is a stimulus to increased secretion of parathormone.

"4. That parathormone effects its control: (a) By stimulating excretion of phosphate

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by the kidney; (b) By mobilizing calcium ions from the storehouse in the bones. Following this mobilization calcium phosphate is formed. This is inactive, can be kept in solution in the blood by parathormone in greater quantities than would normally be the case, and is in a form in which it can be excreted.

"5. That, *vice versa*, if the parathyroid glands are removed, the body will be unable to deal adequately with the blood-phosphate. Excretion of phosphate will be diminished. Calcium ions cannot be mobilized to combine with the phosphate, and so render it inactive and excretable. The only available supply of calcium ions is the diffusible fraction of the serum calcium. J. H. Jones suggested that this falls as it combines with the excess phosphate and so tetany occurs."

Helfet further elaborated this hypothesis, and went on to give his classification of hyperparathyroidism. Since it is not our purpose to discuss here the theoretical background on which the treatment is based, it seems unnecessary to quote the author further. In fact, some of our colleagues and friends, who are more conversant with the hypotheses of calcium and phosphorus metabolism than are we, have expressed the opinion that the hypothesis is incorrect. Be that as it may, our clinical experiences with the use of aluminum acetate have been sufficiently impressive to justify a report of these experiences. In addition to this, we feel that they should stimulate further researches to explain the chemistry behind the results, and either substantiate Helfet's hypothesis or produce a new one acceptable to all.

In order to carry out treatment based on his hypothesis, Helfet felt that an attempt should be made to reduce the intake of phosphorus and "thus remove the stimulus to the over-production of parathormone". He attempted to find an adequate diet of constant low-phosphorus content, but abandoned this as impracticable. Helfet noted that "an alternative method for the reduction of phosphorus intake consists in the feeding of a soluble salt of aluminium". He further noted that the acetate is the most soluble and least astringent of the salts of aluminum. A preparation using honey as a medium to disguise the astringency was prepared and used in his cases. The dose was made as small as possible in order to reduce the danger of any deleterious effect. He cautioned that too large a dose could produce rickets. At least one pint (0.5 liter) of milk a day was prescribed in order to give the patients a source of calcium and vitamin D.

Helfet prescribed what he said was "an amount of aluminium acetate with a phosphate-combining power equivalent to 150 to 220 mg. of calcium", while children were given a smaller dose, "the equivalent of 100 to 150 mg. of calcium per day". To this end a formula was prepared for him as follows:

> Take: One and a quarter fluidounces of liquified aluminium acetate (British Pharmacopoeia), 360 minims of syrup, four minims essence cherry confectio optima, and clarified honey (P.B.) to make four fluidounces. Minimum dose, one fluidram, four times a day, after eating.

Our own pharmacists have prepared an aluminum-acetate mixture for us according to the following prescription:

> Take: Five fluidounces of a solution of aluminum acetate (Burow's solution), three fluidounces of syrup of tolu balsam, and honey to make sixteen fluidounces. Directions: One teaspoonful, three times a day.

It has been our custom with children to reduce the dosage according to the age and size of the patient.

It was found by our pharmacists that, in the process of preparation of aluminum acetate, free lead might be deposited, thus offering a cause for deleterious effects. As soon as this was discovered, the method of preparation was changed, and no further trouble has been experienced along this line. This experience gave rise to some speculation that the apparent increased density of bone seen in the roentgenograms, in cases in which there was improvement under treatment, might be due to the deposition of lead in the bone. In one of our cases, this was proved not to be true.

Helfet recommended the use of aluminum acetate in generalized fibrocystic disease, or what he called secondary pathological hyperparathyroidism; in Paget's disease, in which he noted clinical improvement, with improvement in the roentgenographic appearance in only two of the eight cases treated; and in rheumatoid arthritis.

Our experience has been limited to thirty-four cases, in which patients have had the treatment prescribed, and have been followed long enough for some change to be noted, if any has taken place. There were seventeen cases of osteoporosis, twelve cases of Paget's disease, four of osteitis fibrosa, and one of osteogenesis imperfecta.

OSTEOPOROSIS

The group of cases in which the diagnosis was osteoporosis were for the most part fairly typical examples of senile osteoporosis, although a few involved other parts of the skeleton than the spine. Previous therapeutic measures used in cases of this group—for the most part without any evidence of improvement—were calcium, vitamin D, physical therapy, braces and corsets, roentgenotherapy, stilbestrol, and testosterone. In administering aluminum acetate, the use of milk was recommended in all instances; if milk could not be tolerated by the patient, calcium in some other form was used. Vitamin D was administered in all cases. Braces or corsets were used in fourteen cases, physical therapy was used in seven cases, and a hard bed in fourteen cases.

The review of these seventeen cases of osteoporosis revealed the following: There was no follow-up reported in one case. Treatment had been followed less than six months in six cases (in one of these the patient had a gastro-intestinal upset and had not carried out the treatment). Of the ten patients who had followed the treatment six months or more, eight were improved and two were not benefited. The improvement in the cases of osteoporosis, so far as we know, has been subjective. No roentgenographic evidence of improvement has been noted.

PAGET'S DISEASE

There were twelve cases of Paget's disease, divided equally between the two sexes. In seven of these cases, more than one area was involved; and in five, only one area was involved, so far as our records show. In all but two cases, there was an elevation of the concentration of phosphatase in the serum, the average reading in the twelve cases being 13.8 units per 100 cubic centimeters of serum, and in this group the readings varied from 6.8 to 40.2 units per 100 cubic centimeters of serum. Previous treatment in these cases, without relief of symptoms, had been as follows: roentgenotherapy in two cases, and calcium and vitamin D in two cases.

The results from treatment in this group were as follows: There was no follow-up obtainable in one case. Treatment had been followed less than six months in three cases, —one of the patients of this group had a gastro-intestinal upset, and two did not take the medicine at all. All of the eight patients who followed out the program for six months or more were improved. In the cases of Paget's disease, the evidence of improvement has been on the basis of symptomatic relief. We have not had enough roentgenographic evidence of improvement to be able to state that this takes place.

OSTEITIS FIBROSA

There are four cases which may be classified in the general group of cases known as osteitis fibrosa. We are aware of the tendency toward a changing conception of the terminology used to denote this condition, and particularly aware of the fact that some of these cases have been designated as polyostotic fibrous dysplasia and others, with a certain combination of physical findings, are grouped as examples of Albright's syndrome. It is not our purpose to discuss the relative importance of these suggested changes in nomenclature. Our four cases here reported present somewhat different clinical pictures; yet

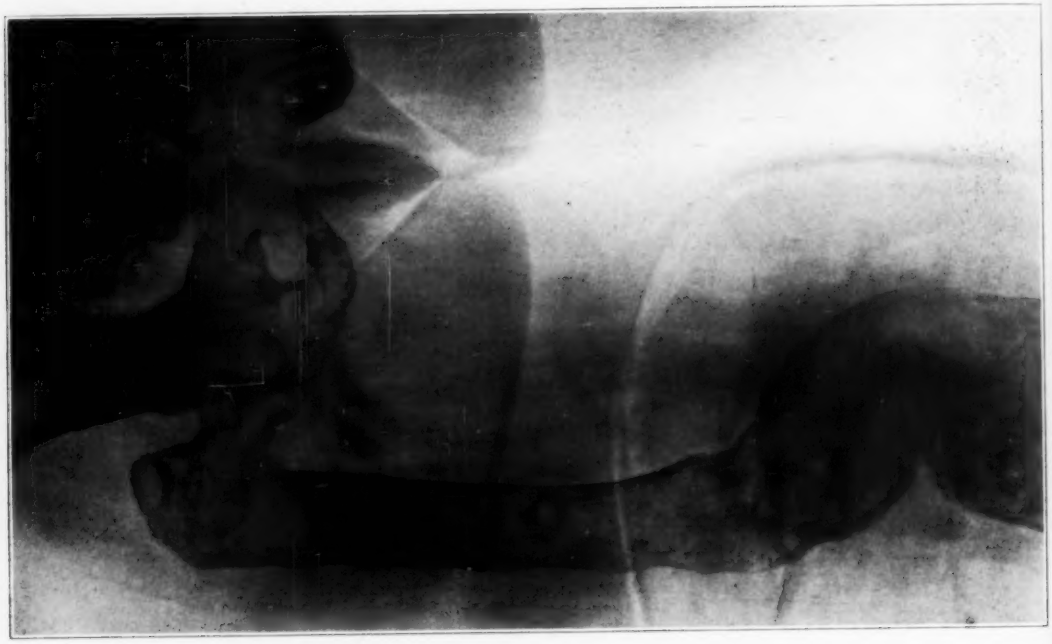

FIG. 1-B

FIG. 1-A

Fig. 1-A: Case 1. Showing extensive changes in the upper part of the femur, the hip, and the pelvis.

Fig. 1-B: After eighteen months' treatment with aluminum acetate. Marked improvement in upper end and neck of femur and in pelvis.

FIG. 2-A

Case 2. Extensive osteitis of the humerus before treatment with aluminum acetate.

FIG. 2-B

After eighteen months' treatment with aluminum acetate.

all must be regarded as cases of osteitis fibrosa, as used in its broadest sense. For this reason, and for the reason that one of these patients has shown a most striking improvement under this treatment, we are presenting abstracts of the case histories. Definite roentgenographic evidence of improvement can be seen in the two cases illustrated. This improvement has accompanied symptomatic improvement. In Case 1, the patient has progressed from confinement in a wheel chair to walking with one cane only.

CASE REPORTS

CASE 1. This patient was a woman, twenty-seven years of age at the time of her first admission to the Mayo Clinic in 1939. Her first symptoms had appeared at the age of four years, as pain in the right knee. At the age of six years, a lump appeared; and at the age of seven, it was noticed that the right ankle was protruding, and pain became more severe. At the age of twelve years, the knee was beginning to be prominent medially. The right leg was longer than the left at this time. At the age of nineteen years, the patient fell and fractured the right ankle. Ten months later the right knee was injured, after which she was on crutches until 1935 (then twenty-three years old). Biopsy was done at this time, and the diagnosis of polyostotic fibrous dysplasia was made. The case was reported by Lichtenstein.

At the time of the patient's visit to the Mayo Clinic in 1939, she was unable to walk at all, but was moved about in a wheel chair. Extensive involvement of the skull, pelvis, spine, right femur, right tibia, and

fibula was noted (Fig. 1-A), with less extensive involvement of some of the other long bones. Sections from the previous biopsy were obtained, and our pathologists made a diagnosis of "osteitis fibrosa with scattered foreign-body giant cells". The concentrations per 100 cubic centimeters of serum were as follows: calcium 9.4 milligrams, phosphorus 1.3 milligrams, phosphatase 16.1 units. It was agreed by the consultants who saw the patient that this was not the usual picture of parathyroid osteitis, and a program of conservative treatment was advised. Thymus extract was used in the hope that some stimulation to deposit of bone would be noted. This was continued for more than a year with no apparent benefit. During all of this time, a diet high in calcium and vitamin D was used. Several courses of localized roentgenotherapy over the areas in the bone most affected were given with little or no improvement. In April 1941, aluminum-acetate therapy was started, and after a few months marked subjective improvement was evident. On the patient's return to the Clinic in June 1942, besides the subjective improvement, roentgenographic examination showed considerable improvement in the amount of calcification apparent in the bone (Fig. 1-B).

At that time there were 9.4 milligrams of calcium, 2.2 milligrams of phosphorus, and 12.5 units of phosphatase per 100 cubic centimeters of serum. Osteotomy was done to correct the bowing of the femur and tibia. Tissue removed at that time again was reported as showing "osteitis fibrosa with a few giant cells, some osteoid tissue, but no actual bone".

The question of the improvement in the roentgenographic appearance being due to lead deposited in the tissues from the lead in the aluminum-acetate mixture was definitely settled by failure to find any lead in the tissue removed at the time of osteotomy. There was a mild degree of basophilic stippling in the blood smear, however, indicating a very mild degree of plumbism.

Subsequent to the operation, administration of aluminum acetate has been continued, and the patient has continued to improve.

CASE 2. The patient, a girl, aged eight years, was admitted in 1939. Eight months previously she had fractured the right humerus. Roentgenographic examination showed fibrocystic disease (Fig. 2-A). Most of the bones of the right upper extremity were involved. She was treated by radiation, calcium, and vitamin D with little if any improvement. In September 1941, she started taking aluminum acetate; improvement followed, although another fracture of the humerus occurred one year later. Roentgenograms show improvement (Fig. 2-B).

CASE 3. The patient was a man, aged twenty-three years, who had had osteitis fibrosa of the left femur with pain for two years. The condition was getting progressively worse. There were 10 milligrams of calcium, 3.8 milligrams of phosphorus, and 3.1 units of phosphatase per 100 cubic centimeters of serum. The patient had not had any previous treatment. The administration of aluminum-acetate mixture was continued for nine months. The patient now does manual labor without pain, except for some aching in damp weather.

CASE 4. This patient, a man, aged thirty-three years, had had osteitis fibrosa of the right ilium and femur for twenty-two years. There were 9.3 milligrams of calcium, 3.4 milligrams of phosphorus, and 2.8 units of phosphatase per 100 cubic centimeters of serum. No other treatment had been used. This patient stopped the treatment in two months on account of a gastro-intestinal upset.

Thus we see that of the patients who had osteitis fibrosa, three improved, and one patient followed the treatment for only two months. The improvement in Cases 1 and 2 is considerable, as demonstrated by the roentgenograms here reproduced.

OSTEOGENESIS IMPERFECTA

One patient who had had osteogenesis imperfecta with repeated fractures and deformities since 1914, and who was unable to work and could hardly get around, improved after six months of treatment with aluminum-acetate mixture and finally was able to get around on crutches and work at a desk. He reported that he felt much better.

COMMENT

The clinical improvement, both subjective and objective, seems to us striking enough to warrant a further trial of the treatment, and should stimulate research to determine what takes place in the physiological chemistry of the body to produce these changes. That aluminum salts will combine with phosphorus in the intestine is well known.[2,6]

In our cases, speculation as to the effect of lead, precipitated in the earlier preparation, seems to have been settled by the failure to find any lead in the tissue removed at the time of osteotomy, in spite of the fact that the patient had evidence of plumbism, as shown by basophilic stippling seen in the blood smears.

TABLE I

RESULTS OF TREATMENT WITH ALUMINUM ACETATE

Disease	Cases	After Treatment of Six Months or More	
		Improved	Unimproved
Osteoporosis*	17	8	2
Paget's disease†	12	8	0
Osteitis fibrosa	4	3	1
Osteogenesis imperfecta	1	1	0
Totals	34	20	3

* There was no follow-up in one case; treatment was followed less than six months in six cases.
† No follow-up was obtainable in one case; in three cases, treatment was followed less than six months.

It is not known how permanent the effects thus produced by aluminum acetate may be, how complete the restoration of the bone by the method is, or what conditions other than those mentioned here may be favorably affected. Table I summarizes our results.

Other salts of aluminum may be used. Helfet stated that he had used aluminum gluconate. A similar chemical process has been noted by Liu and Chu in treating renal osteodystrophy by means of the oral administration of iron salts.

The whole subject opens up new methods in the treatment of these interesting types of malacic disease of bone.*

REFERENCES

1. BLACK, J. R.; GHORMLEY, R. K.; AND CAMP, J. D.: Senile Osteoporosis of the Spinal Column. J. Am. Med. Assn., CXVII, 2144, 1941.
2. FAULEY, G. B.; FREEMAN, SMITH; IVY, A. C.; ATKINSON, A. J.; AND WIGODSKY, H. S.: Aluminum Phosphate in the Therapy of Peptic Ulcer. Effect of Aluminum Hydroxide on Phosphate Absorption. Arch. Int. Med., LXVII, 563, 1941.
3. HELFET, A. J.: A New Conception of Parathyroid Function and Its Clinical Application. A Preliminary Report on the Results of Treatment of Generalized Fibrocystic and Allied Bone Diseases and of Rheumatoid Arthritis by Aluminium Acetate. British J. Surg., XXVII, 651, 1940.
4. LICHTENSTEIN, LOUIS: Polyostotic Fibrous Dysplasia. Arch. Surg., XXXVI, 874, 1938.
5. LIU, S. H., AND CHU, H. I.: Treatment of Renal Osteodystrophy with Dihydrotachysterol (A. T. 10) and Iron. Science, XCV, 388, 1942.
6. STREET, H. R.: The Influence of Aluminum Sulfate and Aluminum Hydroxide upon the Absorption of Dietary Phosphorus by the Rat. J. Nutrition, XXIV, 111, 1942.

* Although Helfet reported a positive calcium balance in a case of generalized osteitis fibrosa cystica while the patient was taking aluminum acetate, no change in the calcium balance was noted in two instances in which studies of calcium balance were carried out on patients under observation and treatment with aluminum acetate at the Mayo Clinic. This further confuses the picture and, as far as accepting Helfet's hypothesis as to what takes place is concerned, leaves us more in doubt. We do feel, however, that the improvement noted in the cases reported here justifies further clinical trial of the treatment.

RUPTURE OF THE PLANTARIS MUSCLE

BY CAPTAIN EDMUND J. CROCE AND MAJOR GEORGE K. CARPENTER

Medical Corps, Army of the United States

Tears of musculotendinous systems may be the result of either direct or indirect trauma. The mechanism of tearing as a result of direct trauma is quite obvious. There has been much speculation and little experimental study of the mechanism of indirect trauma,—that is, trauma caused by muscle action. If the muscle or tendon is diseased or has undergone degeneration, it may tear as a result of ordinary muscle contraction. If it is normal, it is supposed that tearing is the result of abnormal muscle contraction, asynchronous contraction of antagonists, or a spiral twist of the limb. Experimental study has revealed that, when abnormal strain is placed upon a musculotendinous system, it tears, in order of frequency, at its tendinous insertion, in its muscle belly, or at the musculotendinous junction. A normal tendon does not rupture until it has been reduced to half its normal caliber.[1] Clinically, however, tears occur in normal musculotendinous systems in the following order of frequency: in the muscles of the calf, the extensor muscles of the leg, the biceps brachii, the Achilles tendon, the supraspinatus tendon, the rectus femoris muscle, the extensor tendons of the fingers and of the thumb, the adductor muscles of the thigh, and the triceps muscle.[1] It would therefore seem that tears of tendons do occur fairly frequently, but the view is held, although not statistically substantiated, that these tendons have been previously weakened by disease, trauma, or aseptic necrosis.

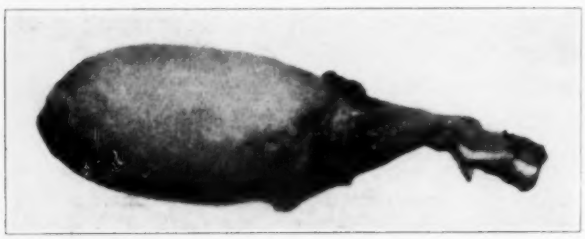

FIG. 1

Tumor surgically removed from the popliteal fossa.

In view of these clinical and experimental data, it is difficult to properly evaluate the supposedly common tear of the plantaris tendon in the plantaris syndrome, or tennis leg. This syndrome occurs more frequently in middle-aged individuals, especially in those athletically inclined. The patient feels as though he had been suddenly hit or struck in the calf, and sometimes is aware of something snapping inside it. Thereafter, he finds it painful to bring his weight down on his heel and walks preferably on his toes. There is tenderness over the central portion of the upper third of the calf. Three to six days later ecchymosis may appear in this area, or along either or both sides of the calf muscles.

The syndrome is so little disabling and is so self-limited that it has not lent itself to further clinical investigation. Bristow, however, is reported to have operated upon sixteen patients, and found that the musculotendinous system of the plantaris was intact in all.[2] He concluded that the symptoms and signs were caused by minor tears of muscles of the calf.

It is not clear what the immediate cause of this syndrome is, nor is the end result of nature's reparative process definitely known. Therefore, it is considered valuable to report the following case, unusual and interesting from several aspects, although it does not strictly fall into the plantaris syndrome, first, because the cause was direct trauma, second, because the tear occurred near the origin of the muscle belly, and third, because it resulted in a degenerative tumor of the muscle.

CASE REPORT

A white soldier, twenty-two years old, entered an Army General Hospital July 29, 1943, complaining of a tumor mass in the left popliteal fossa. He stated that he had been engaged in mass athletics on Febru-

ary 14, 1943, when his partner accidentally struck him in the left popliteal fossa with the heel of his shoe. On standing, he felt as though his left leg had a charleyhorse. He tried to work it off by running, but he felt something ripping behind the left knee and stopped. The next morning, the left knee was somewhat stiff; he could not straighten it completely, and flexion was painful. About two weeks later, approximately February 28, 1943, while taking a bath, he noted a lump behind the left knee, and about the same time a wide-spread greenish discoloration of the popliteal fossa for six inches above and below it. In the next three weeks, the discoloration gradually disappeared, but the lump remained about the same; it became painful after a long march. About five weeks after the original injury, while making a hard run for a fly during a

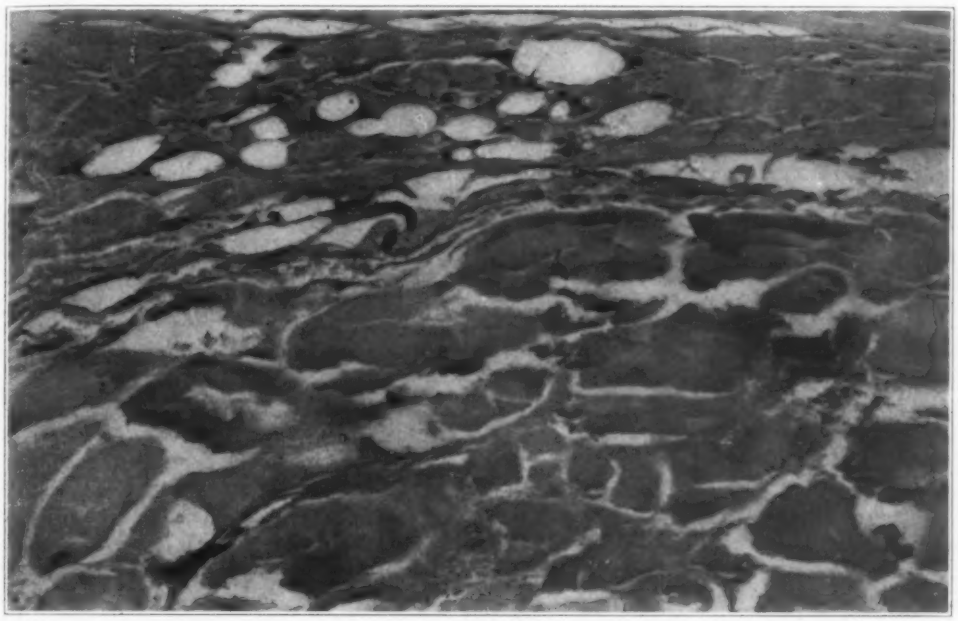

FIG. 2

Microscopic section showing Zenker's degeneration of muscle.

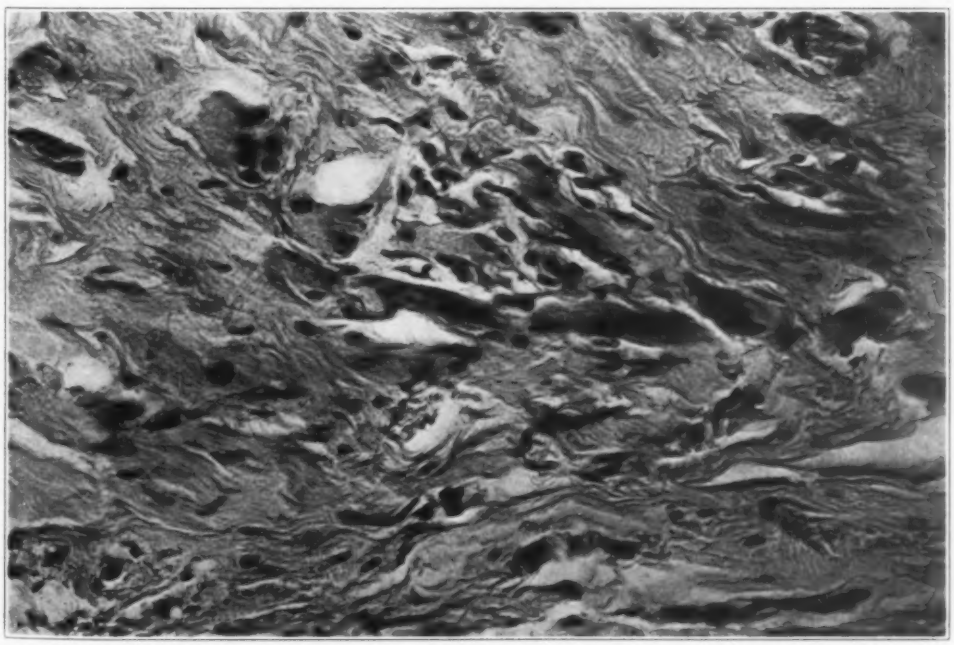

FIG. 3

Microscopic section showing foreign-body giant-cell reaction along the tendinous attachment.

ball game, he felt something rip again in the same region, and had almost the same symptoms and signs as after the original injury, but to a less extent, and for a shorter period. This second accident was not followed by any ecchymosis, however, only by slight swelling and pain; he did not notice any change in the lump, in size or otherwise, during or after this accident. Symptoms subsided, and returned only after long marches. The patient completed his basic training. During a routine examination in a staging area, the tumor was noted, and he was eventually admitted to an Army General Hospital.

Examination revealed nothing remarkable except for findings in the left lower extremity. Extending upward from the left popliteal fossa, just lateral to the medial hamstring tendon, was a firm, non-tender pear-shaped mass, about 6 by 2.5 centimeters in dimension, round above, tapering below into a cordlike structure, which soon plunged deeply behind the gastrocnemius. The mass was movable only very slightly above, and was well fixed below. Motions of the knee were normal, and the patient walked without a limp.

Roentgenograms of the knee revealed no abnormality. Other laboratory data were normal.

Operation was done on August 6, 1943. An incision, five inches long, was made along the medial aspect of the popliteal fossa overlying the mass which lay beneath the deep fascia, well-encapsulated, pyriform, and lateral to the medial hamstring tendon. Its capsule was incised, and a few drops of glairy fluid escaped. Within this capsule was a firm, yellow mass, rounded and free above, tapering and attached below to a tendon. The capsule was attached to the deep fascia above, and to the junction of the mass with the tendon below. The incision was extended downward in the direction of the tendon in an attempt to identify it. From its caliber, position, and skeletal action, it was felt to be the plantaris. The tendon was transected about two inches below the mass, and its distal end was sutured to the adjacent muscle. The mass and its capsule were dissected out. The skin and deep fascia were approximated with interrupted silk, and a posterior plaster splint was applied with the knee in slight flexion.

The patient's convalescence was uneventful, and he returned to duty in two months.

Pathological examination of the specimen showed a buff-colored, smooth mass 6 by 2 by 1.5 centimeters attached, at one end, to a tendon-like cord, 5 centimeters in length (Fig. 1). On section, the mass appeared to be composed of bundles of degenerated muscle fibers, arranged in herringbone pattern, and continuous into the tendon. The bundles were yellowish-gray in color, with a more or less regular mottling of orange-yellow pigment, most marked around the periphery. Microscopic examination revealed Zenker's degeneration of voluntary muscle (Fig. 2). Scattered between the muscle bundles were deposits of hemosiderin. Along the line of the tendon attachment, there was marked foreign-body giant-cell reaction (Fig. 3), the giant cells engulfing portions of degenerated muscle; adjacent to this was considerable fibrous granulation tissue, containing many small vessels, the endothelial cells of which contained considerable hemosiderin.

DISCUSSION

Reconstructing the events in the light of operative and pathological findings, it would seem that the plantaris, which was unusually well developed, and thus was exposed above the origin of the lateral head of the gastrocnemius, was torn from its origin along the linea aspera by the blow from the opponent's heel, and probably at the same time was deprived of its blood supply from the genicular arteries; a degenerative reaction of the muscle belly resulted.

REFERENCES

1. McMaster, P. E.: Tendon and Muscle Ruptures. Clinical and Experimental Studies on the Causes and Location of Subcutaneous Ruptures. J. Bone and Joint Surg., XV, 705, July 1933.
2. Tucker, W. E.: Athletic Injuries. *In* Rolleston's British Encyclopaedia of Medical Practice, Vol. II, p. 235. London, Butterworth and Co., Ltd., 1936.

HERNIATION OF THE NUCLEUS PULPOSUS

A Study of One Hundred Cases Treated by Operation *

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The relief from sciatic pain resulting from removal of a herniated nucleus pulposus is so dramatic that, in many cases, the persistence of pain in the lower back may be overlooked by the surgeon, who is well satisfied with having accomplished so much for his patient. It is a fact, however, that these cases frequently present a combined neurological and orthopaedic problem, and if one is treated by a neurosurgeon or an orthopaedic surgeon alone, the features of the case pertaining to the other specialty are likely to be submerged or overlooked. It is our belief that all cases of sciatica should be studied by a neurosurgeon and an orthopaedic surgeon, working together as a team, each familiar and sympathetic with the other's point of view.

The recognition of herniation of a nucleus pulposus as a cause of pain is quite recent. We still are in the stage when new and important facts are constantly being brought forth, which give us a better understanding of the subject, and we are having to modify our ideas in the light of new knowledge. This study of 100 cases of herniation was made in order to report our experience at the New York Orthopaedic Dispensary and Hospital and to present our current ideas on the subject. Certain data pertaining to pathology and diagnosis are based on the entire 100 cases. The results of treatment are computed from only seventy cases, because the condition of the remainder is known for less than one year after operation.

It is our conviction that in many instances of herniation, there is a deranged or unstable lumbosacral joint. This is important, because it may give rise to a weak and painful back. The existence of this condition not only is demonstrated by roentgenographic studies, but, in many cases, is also suggested by a history of low-back pain for some time prior to the sciatica. As an explanation of many cases of herniation, the theory is offered that the disc and overlying ligament may be weakened from the increased strain incident to an unstable joint. There is evidence that, in some cases, after removal of a herniated nucleus pulposus, the disc becomes thin or even largely disappears; such a result might reasonably be expected in the majority of cases. It is well known that destruction of the nucleus and thinning of the disc, aside from a herniation, causes a mechanical derangement of the joint, which often results in a painful back. This condition has been found in several of our patients who did not have a spine fusion, and may develop in others later. A sufficient length of time after operation has not elapsed to determine the validity of this theory; but all of these patients should be followed for a period of years; and the possibility of such an occurrence should be borne in mind. We should not accept the immediate relief of sciatic pain as evidence of a complete cure in these cases.

In this series, a spine fusion was done in connection with removal of the nucleus in eighty-three cases. The indications for the fusion were an unstable joint, as determined by roentgenogram, with or without symptoms of back pain. It probably is true that in some of these a fusion would not have been done, if it had not been necessary to remove the nucleus. The Hibbs method was employed; this procedure is done easily with exploration of the interlaminar space, especially since a technique has been developed which

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 2, 1944.

permits exposure of the disc laterally, and excision of the herniation with the removal of very little bone. The time of operation is not greatly prolonged by the addition of fusion; nor is the time in bed or the total period of disability much greater.

Before we were aware of the existence of herniation of the nucleus pulposus, it is probable that a number of patients were relieved by a spine fusion alone. We do not believe that this operation, without removal of the herniation, ever should be relied upon, because of the uncertainty of the result, and because exposure of the disc after a spine fusion is so much more difficult.

This study was based on 100 consecutive patients, with herniation of a nucleus pulposus, who were operated upon at the New York Orthopaedic Dispensary and Hospital from January 1937 to April 1943. The ages of the patients ranged from sixteen to seventy-one years, and the average was thirty-seven years; 80 per cent. of the patients were between twenty and fifty years of age. There were fifty-five males and forty-five females. Their occupations were: housewives, thirty; artisans, sixteen; laborers, thirteen; sedentary workers, eleven; cooks, six; nurses, five; students, three; unknown, sixteen.

Low-back pain or ache in some degree was present in all but one patient. This varied in duration from one month to twenty years. In about one-half of the patients, it had existed from one to five years. In one-fourth it had been present for less than one year. The back pain varied in intensity and in most cases was intermittent.

Because in this Hospital herniated nucleus pulposus is considered a problem concerning both the neurosurgeon and the orthopaedic surgeon, the operation is performed by the joint effort of these two specialists. With two exceptions, the herniation was dealt with by one of us (E. M. D.), the neurosurgeon of this group. The fusion was done by various members of the orthopaedic staff. Fusion was done in one or more joints in 83 per cent. of the cases. In all of the fusions the Hibbs technique [2] was employed. In seventeen cases it was considered unnecessary or inadvisable to do a spine fusion. To these may be added thirteen, in which the rupture was at the fourth lumbar disc, but in which fusion was done only at the lumbosacral joint. Thus 30 per cent. of the patients had removal of the herniation without fusion of the corresponding joint.

SYMPTOMS AND PHYSICAL SIGNS

Five patients stated that the degree of pain in the back and in the lower extremity was of equal severity. Five said that their back pain was the more severe. Forty-three considered the pain in the limb more severe. In forty-seven cases, the patient either could not tell which pain was worse, or their answers to this question were unrecorded. It may have been that in the majority of this last group, more careful questioning would have brought out the answer that the pain in the lower extremity was the more severe. The relative severity of the two pains, as given in the history, is, however, a point that cannot be accepted too literally. The sciatic pain in this group is the more recent and, because it is new and often severe, is mentioned frequently. Patients who have had many years of intermittent low-back pain which they have come to accept, and who are confronted with a new sciatic pain, generally tend to stress the newer complaint.

In practically every case, the history of low-back pain was an old story, antedating the sciatic pain. The actual duration of the sciatic pain varied greatly. The shortest history of sciatic pain caused by a verified herniated nucleus was one month, the period in two cases. The longest history was ten years, the period in four cases. The duration of the sciatic pain in the majority of the patients varied greatly between these two extremes. Sciatic pain was increased with coughing or sneezing in fifty-five cases. In forty-five cases, the patient was either not sure, or the fact was not recorded in the history.

Lumbar lordosis was decreased or obliterated in 61 per cent. There was marked limitation of motion in the lumbar region in 22 per cent., and moderate limitation in 13

per cent. A list of the trunk away from the affected side was noted in 39 per cent., and toward that side in 9 per cent. Increase in sciatic pain produced by bending toward the involved side was mentioned in 19 per cent., and toward the other side in 3 per cent. The pain in the extremity was made worse by all spine movements in 21 per cent. A limp on the side of the lesion was noted in 5 per cent.

Tenderness to light pressure over the area of the sciatic nerve was present in seventy-six patients. The fourth lumbar interspace was tender in twenty-one instances; the lumbosacral space, in forty-seven; and the sacro-iliac region, in eight. Straight-leg raising was limited in 70 per cent. of the patients. Forty-six herniations involved the right side, and fifty-four the left; three of the patients had two herniations each. One patient, with a large mid-line herniation, naturally had pain in both limbs.

In addition to pain, forty-five patients had noticed a certain amount of numbness of the skin on the affected side. This was generally below the knee, and, depending upon the location of the herniation, was located on the outer side of the leg (a lumbosacral interspace herniation), or along the inner side of the foot and big toe (herniation at the fourth lumbar interspace).

Twenty-three patients had noted some degree of motor weakness of the affected extremity, but none could be specific about this point. Two patients showed hyperaesthesia on the outer aspect of the leg on the painful side. Seventy-nine patients showed the characteristic reduction in sensation in the distribution of the fifth lumbar and first and second sacral nerve roots or in the first and second sacral nerve roots depending upon the level of the herniated nucleus. The diminution in sensation varied from marked to slight. In two-thirds, light touch was lost entirely. This test is performed by using a light rubber band or a piece of cotton, with the subject's eyes closed. Pain sensibility is tested by pin point. The average patient exhibited a real decrease, but rarely a loss, of pain sensation in the affected dermatomes.

We have found that the sensory changes are generally more reliable in showing the level of the herniation. If sensation is diminished on the outer side of the foot and ankle, the dermatome of the first and second sacral nerve roots, we expect to find the herniation at the lumbosacral interspace, on that side. If, in addition, sensation is diminished on the big toe and along the inner side of the foot, the dematome of the fifth lumbar nerve root, the herniation is more likely to be found at the fourth lumbar interspace on that side. It has been our experience that neither motor signs nor a narrowed intervertebral space, as shown in the roentgenograms, can be relied upon to indicate the exact level of a herniation, whereas sensory changes are more to be relied upon.

Weakness is the least common objective motor sign, but was definitely present in fifty-three patients. The most reliable method of testing for it is to have the patient dorsiflex the feet against the downward pull of the examiner's hands. Muscle atrophy on the affected side was present in eighty-eight patients, although slight in some cases. It must be carefully looked for, however. The circumference of both limbs should be measured exactly six inches above and below the patellae, and compared. If sciatic pain, caused by a herniation, has been present for even as short a time as a month, the painful extremity often will prove to be smaller in circumference. Inspection of the gluteal muscles frequently will show some flattening and atrophy of the muscles on the affected side.

Of reflex changes, the best known, commonest, and by far the most reliable, in making a diagnosis of a herniation (but not its level), is the ankle jerk. In the present series, the ankle jerk was either definitely diminished or entirely absent in eighty-five patients.

The location of the herniation was as follows: one was between the third and fourth lumbar vertebrae; sixty-two were between the fourth and fifth lumbar, and forty were between the fifth lumbar and first sacral vertebrae. Three patients had herniations between both the fourth and fifth lumbar vertebrae and the fifth lumbar and first sacral. Forty-six of the protrusions were on the right side, and fifty-seven were on the left.

A definite history of trauma of some sort, in relation to the onset of the sciatic pain, was obtained in 46 per cent. of the cases.

SPECIAL TESTS

Routine roentgenograms as an aid in the diagnosis of the presence or level of a herniation, have not been found of value. A narrowed intervertebral space, as shown in the roentgenograms, is not reliable evidence of the presence of a herniation or of its level. Our experience with roentgenograms is similar to that of practically all other clinics, routinely dealing with such herniations.

Spinal manometric and spinal-fluid protein tests were carried out routinely in every patient during the earlier years. In the present series, all the manometric tests which were done were normal. Protein determinations were made in two fractions of the fluid withdrawn. The average protein readings were: first fraction, fifty-eight milligrams; second fraction, forty-nine milligrams. Thus the typical herniation causes a slight increase in spinal-fluid protein. In the more recent cases, we have omitted lumbar puncture in many instances, because it seems to be unnecessary, except when tumor of the spinal cord is considered as a possibility.

Lipiodol or other similar tests have not been used in this Clinic. Instead, we divide the patients into two groups before operation. When neurological signs are convincing and characteristic, a definite diagnosis of herniated nucleus is made. We expect to find the herniation at operation and almost always do. When neurological signs are less definite or are unconvincing, but the degree of sciatic pain is great, a herniated nucleus is suspected. In these cases, especially if a spine fusion has been decided upon, exploration of the spinal canal is advised, and the patient fully understands beforehand that a definite diagnosis has not been made. The number of such explorations in cases of suspected herniation is increasing steadily every year, and we are finding out that over half of these patients prove to have a herniated nucleus pulposus.

The criteria for determination of an unstable or mechanically deranged lumbosacral joint, as seen in roentgenograms, were any one, or a combination of two or more, of the following: asymmetrical lateral articulations, anterior or posterior displacement of the fifth lumbar body, exaggeration of the lumbosacral angle, a thin intervertebral disc, and a transitional or partially sacralized lumbosacral vertebra. According to this classification, there were eighty-four abnormal lumbosacral joints and twelve stable. The findings were not recorded in four cases. A thin intervertebral disc was found in forty cases, but in only twenty-two was it the disc in which the nucleus was herniated.

THE OPERATION

The method of removal of the herniated nucleus has undergone changes in this Clinic,[1] as it has in others. The earlier operations were generally regular laminectomies, with opening of the dura. It later became more usual to perform a hemilaminectomy, retract the unopened dura medially, and remove the nucleus. More recently, the hemilaminectomy has been found unnecessary in most cases, and the nucleus has been removed through the interlaminal space. This is the standard procedure now in use in this Hospital. At the present time, there is no accepted term to describe the operation of exploring the interlaminal space without doing a laminectomy.

The operation is done on a special table which places the patient in the kneeling position with the hips flexed 90 degrees. This facilitates greatly both the exploration of the disc and the spine fusion, if one is to be done. We consider this positioning an important point in the technique. The tendency of some operators to strive for smaller and smaller incisions and exposures is a needless and dangerous refinement. Small, cramped exposures save little or no time, nor do they decrease the operative risk, which is negligible anyway. We have seen a sufficient number of negative explorations, carried out in other

clinics through tiny exposures, to feel convinced that the lack of exposure is often directly responsible for the failure to find and remove the herniation.

THE POSTOPERATIVE PERIOD

The relief of sciatic pain after removal of a herniated nucleus was often immediate and definite. A few patients needed to be catheterized for a day or two following operation. We have found that elevation of the head of the bed on shock blocks (after blood pressure and pulse have become normal) for a day or two helps to prevent or to shorten the time during which voiding is difficult.

Practically all patients noted and many complained somewhat of increased numbness of the affected extremity after removal of the nucleus. This condition is apparently due to traction on the nerve root to the medial side during removal of the nucleus. It is a temporary symptom and clears up within a week or two after operation.

Postoperative treatment for the patients who had had a spine fusion frequently included a blood transfusion. A Taylor spine brace was applied while the patient was on the operating table, and was worn continuously. At the end of six weeks, if the roentgenogram was satisfactory, the patient with spine fusion was allowed up, wearing the brace. This usually was continued for four months or longer, if the roentgenogram revealed a light fusion. Normal activities usually began about five months after the operation. The patients with uncomplicated spine fusions spent an average of fifty-four days in bed and sixty-six days in the Hospital. The complications hereafter mentioned increased the total average to sixty days in bed and seventy-seven days in the Hospital. Patients without fusion were out of bed on an average of eighteen days after operation, and left the Hospital in twenty-five days.

There were no deaths in this series. In fact no death has occurred in this Hospital as a result of spine fusion for any reason during the past nine years. There was an uneventful postoperative course in seventy cases. The most important complication was a low-grade infection in the disc from which the herniation was removed. It was found in three cases, in all of which the fourth lumbar disc was involved. In each instance there was some elevation of temperature. The chief symptom was severe and persistent back pain. After several weeks, roentgenograms revealed a destructive process in the adjacent vertebral bodies. The discs in two patients were drained, and one patient recovered without drainage. A spontaneous fusion of the involved bodies, as shown by roentgenogram, took place in each of the three cases. Superficial wound infection occurred in four other cases and a stitch abscess in one. In five patients urinary retention required catheterization for a few days. In the early operations, when the dura was opened, signs of meningeal irritation were observed twice, but there were no instances of true meningitis.

Peroneal palsy with foot-drop occurred once. An ankle fusion gave a very satisfactory result in this case. One patient had iliofemoral thrombophlebitis with pulmonary infarcts. Another had acute coronary occlusion. Each made a good recovery.

Other operations were performed either before or after removal of the herniation for relief of pain. In eight cases, an Ober fasciotomy was done. Three times it proved unsuccessful as a primary procedure, and in one patient a herniation was removed later. In two patients, the fasciotomy was done after the herniation had been removed. One of these is without follow-up record. The other, still unrelieved, has symptoms suggestive of a herniation in another disc.

One unusually complicated and difficult case was first seen in 1940. The diagnosis of herniation had been ruled out in another clinic, as well as in our own, on the basis of both a negative clinical examination and a negative lipiodal myelogram, done elsewhere. A fusion of the lumbosacral joint was done. This failed to relieve the patient and a later examination revealed signs leading to a diagnosis of a suspected herniation. One was found and removed from the fourth lumbar disc. Because the patient continued to com-

plain of back pain, a fusion was done between the fourth and fifth lumbar vertebrae. Finally, in 1942, persistent stiffness and pain, with contracture of the fascia lata, induced us to divide this structure in both thighs. He has now improved sufficiently to coach a soccer team, in addition to carrying on his regular duties as a teacher.

The spine fusion failed in eight cases; these were repaired at a second operation. A pseudarthrosis was diagnosed in two other patients who refused repair operations; thus the total incidence of failure of fusion probably was 12 per cent. Repair of the pseudarthrosis gave an excellent result in three, good in two, and poor in three cases.

RESULTS

All patients included in this study have had a follow-up of at least one year. The results of treatment are based only on those seventy patients who were examined one year or more after operation. A rating of "excellent" was given to those who were entirely free from pain, and were able to return to the same or equivalent occupations as they were engaged in before the onset of symptoms. The result was called "good" when slight pain was felt, but when there was no disability. In those who had sufficient pain to cause partial or complete disability, the result was considered "poor". Computed on this basis, there were twenty-four excellent results, thirty-three good, and thirteen poor. It should be pointed out that the existence of either back or sciatic pain is taken into consideration in evaluating the result.

There were thirty cases in which the data were insufficient, either because the follow-up period was too short, or because the records were incomplete. The last examination in these cases indicates that the results in twenty-two were good and in three were poor.

Either because there was no indication for a spine fusion or because the patient's condition did not warrant doing one, seventeen patients had a herniated nucleus removed without spine fusion. In the twelve of these cases whose records are complete, the result was excellent in five, good in five, and poor in two. As has been pointed out, the evaluation of these cases should not be considered final until they have been observed for a much longer time.

SUMMARY

In this study of 100 cases in which a herniated nucleus pulposus was removed, all patients had sciatic pain, and, with one exception, all had back pain, preceding or coincident with the sciatica. Roentgenographic or clinical examination revealed an unstable lumbosacral joint in eighty-four cases. A spine fusion was done at the time of removal of the herniated nucleus in eighty-three cases. The results in seventy cases with complete records one year or more after operation were twenty-four excellent, thirty-three good, thirteen poor.

REFERENCES

1. DEERY, E. M.: Herniation of the Nucleus Pulposus as Complication of Pre-Existing Low Back Instability. Surg. Gynec. Obstet., LXXVII, 79, 1943.
2. HOWORTH, M. B.: Evolution of Spinal Fusion. Ann. Surg., CXVII, 278, 1943.

DISCUSSION

CAPTAIN JOSEPH S. BARR, BOSTON, MASSACHUSETTS: This is an interesting and important paper. I have read it two or three times, and it contains a great many points which require discussion. I will take up several of these.

One of the points which the authors have brought out in the paper is the hypothesis that an unstable lumbosacral joint is the cause of ruptured disc. They found unstable lumbosacral joints in some 87 per cent. of their cases, and they have fused the joint at the time the disc was removed. Their criteria as to what constitutes an unstable joint apparently includes all the abnormalities which may be seen in the roentgenogram. Dr. Badgley published a paper some time ago, in which he compared the occurrence of abnormalities seen in the roentgenogram of patients with low-back and sciatic pain, and those without symptoms. In 27 per cent. of patients without symptoms anomalies were found, and in 25 per cent. of those with sciatic pain

anomalies were present. I suspect that, with one exception, there is no correlation between the presence or absence of ruptured disc and the presence or absence of congenital anomalies. Spondylolisthesis is the exception to that rule.

This paper indicates that the authors have performed fusion operations on about 83 per cent. of their patients. We have been doing spine fusions on about 30 per cent. at the Massachusetts General Hospital. At some clinics the percentage of fusion operations is nil. How many spines should we fuse? I do not think as yet we know the answer to that question. I believe that the Military Services could go a long way toward solving this question, as they have a group of men of similar age and similar occupation. If alternate cases were treated with and without spine fusion, and the end results were compared, we might be able to ascertain the value of spine fusion, and in a short time we would know whether fusion is worth while or is not worth while.

In the part of the paper that was not read, it is mentioned that the lumbosacral joint was fused in a certain number of cases in which the disc lesion was between the fourth and fifth lumbar vertebrae, on the hypothesis that there was instability of the lumbosacral joint. I personally feel that, if fusion is going to be done at all, it should always include the vertebrae on either side of the involved disc. If the lesion is at the lumbosacral joint, the fusion should be limited to that area. With the modern technique of removing the disc, the spinous processes do not need to be removed, and there is little sacrifice of the laminae. That makes the technique of fusion a good deal simpler, as there is a relatively short gap to bridge. There are several satisfactory techniques for spine fusion, but a certain percentage of failure occurs no matter which method is used.

For several years, we have used a short massive tibial graft, wired firmly to the spinous processes or inserted between the spinous processes as a clothespin graft. This technique produces immediate firm immobilization. The trend is toward early ambulatory treatment, thus avoiding the physical and mental deterioration associated with prolonged bed care.

Dr. J. Albert Key, St. Louis, Missouri: I agree with Dr. Smith in a good many things mentioned in his paper. First, on the diagnosis: I think the diagnosis should be made on the history and on the physical examination. Strange to relate, I agree with Dr. Dandy that the history is the most important factor, certainly from the standpoint of whether or not we are going to operate upon these patients, because the ones to be operated upon are the ones who have had disability over a sufficient period to warrant it, or who have a disability of sufficient degree, which cannot be relieved by non-operative means. I do not think that more than 10 per cent. of these patients should be operated upon; at least not more than 10 per cent. of the patients I see, and on whom I have diagnosed a protruding disc. We know that these patients have become well in the past, and have remained well, some for long periods. In some cases the symptoms have recurred. The fact that the herniation of the disc may recur is not sufficient reason to operate, if it can be relieved temporarily, so that the patient can be economically satisfactory to himself and his community.

Another point is that this operation is not a simple procedure, at least in my hands. In some, the operation proceeds smoothly to completion without special incident; and, in some, the opposite proves definitely to be the case.

You cannot make a diagnosis as to localization of the disc from the neurological signs. The most important factor in my experience is tenderness, whether it is between the fourth and fifth lumbar vertebrae or the fifth lumbar and first sacral vertebrae. Even when that indicates that the disc is at one level, it is sometimes found at another level. Not infrequently two protruding discs are found. I think both should be removed if possible. Because of the fact that the principal difficulty in the operation is the control of bleeding, I no longer attempt to remove the disc without taking out a large button of bone from the lamina in order to have room to control the bleeding if necessary.

I do not think an operation should be performed with the idea that the disc is not going to be found and that fusion of the spine will suffice. I am fusing fewer and fewer spines for low-back pain and sciatica. The cases in which I had the worst results were those in which I fused the spine because I did not find the disc. I have had three cases in which I reoperated after fusion failed, and two of those patients are better. When you reoperate on a fused spine to expose a disc, you have a very hard job.

There is one point about fusion which I have found very practical, and that is the small square graft taken from the outer cortex of the ilium and wedged between the spinous processes. I do all these under local anaesthesia, because I think the convalescence is more smooth. After that, the patient may be allowed up in a lumbosacral belt in three weeks. I do not mean that the spine is fused in three weeks, but it becomes fused while the patient is on his feet.

I do not think Dr. Smith's results with a high percentage of fusion are any better than mine with almost no fusions.

Dr. Frank R. Ober, Boston, Massachusetts: It is a good idea to keep this subject before the medical profession in papers of the sort which Dr. Smith has just read, since the diagnosis of disc lesions is still a matter of considerable debate.

It must be remembered that there are other things beside ruptured discs which can produce pain in the course of the sciatic nerve. It seems difficult to understand that all cases of pain along the sciatic nerve are due to disorders of the disc, if or when a disc is not ruptured. Certainly when a disc is not ruptured, it cannot press on a nerve root. Furthermore, there are a host of individuals who suffer pain along the sciatic nerve temporarily, who are relieved by their family doctor, and who never get into the hands of orthopaedic surgeons or neurologists.

There is no question in my mind, but that there is a relation between the contracted fascia lata, as a precipitating factor, in the production of lame backs and even of ruptured discs. Ruptures of the disc are usually produced by sudden forward flexion of the spine, and a contracted fascia lata and short hamstrings limit full forward flexion of the trunk on the hips. These individuals, not having normal forward excursion of motion, are more vulnerable to spine injuries.

There are, without doubt, many spontaneous recoveries from ruptured discs; therefore, it would seem logical that patients with a ruptured disc should be treated conservatively by means of a well-fitted corset which supports the spine and the abdomen. The corset is advised, because it fits the back in the sitting position as well as in the standing position. This no brace will do.

We are hearing much ado about typical signs of a ruptured disc. There are no typical signs of a ruptured disc, but there may be typical signs of nerve-root pressure, and it must be borne in mind that many instances of nerve-root pressure may be due to other factors than a ruptured disc. In my mind, it is a bad principle for anybody to make a diagnosis of ruptured disc, because of pain along the sciatic nerve and an absent knee jerk, if he knows nothing about the mechanics of lame backs.

A little over two years ago, I did a fasciotomy on a boy of fifteen for the relief of sciatica. There was temporary relief with recurrence later. It was demonstrated on neurological and lipiodol examination that the fourth nucleus pulposus had ruptured. At operation the neurosurgeon found that there was also a ruptured disc between the fifth lumbar and first sacral vertebrae. The discs were removed. A year and a half later, the patient still has the same sciatic pain.

In a second case, the patient had an absent ankle jerk with pain and numbness along the sciatic nerve. Lipiodol examination showed a defect, and a diagnosis of ruptured disc was made. At operation, there was no sign of any ruptured disc. This patient had a fracture of an articular facet with thickening about the foramen. The spine was fused in this case, and the patient is making an excellent recovery.

A great many patients in the Army and in industry seem to have a long recovery period; in fact, many of them do not seem to want to recover. It must be remembered, therefore, that there is a psychosomatic problem in many low-back cases with and without surgery.

Although Dr. Smith's cases would seem to show that the percentage of results is a little better in the cases which were not fused than in those which were fused after removal of the disc, it is so simple to use spinous processes to cover the denuded bone that one would feel the back would be more stable, if the fusion operation was also carried out after the disc was removed.

Dr. Alan DeForest Smith, New York, N. Y. (closing): I would like to answer briefly some of the points brought up. The diagnosis of instability of the lumbosacral joint and the decision to do a spine fusion in these cases was not made from the roentgenographic findings alone, but from the history of long-continued back pain and clinical evidence of lumbosacral strain. We are now fusing the fourth and fifth lumbar vertebrae in addition to the lumbosacral joint, if a herniation is found at this level. Dr. Phemister asked if any harm had been done by doing spine fusions. I would answer that there had not, except in the few cases in which fusion failed to take place and it was necessary to do a second operation. In my opinion, internal fixation is desirable in performing a spine fusion, and I believe that it should be used, if applicable to the particular case. Conservative treatment had been carried out in all of these cases before the operation was performed.

Fasciotomy has its place in the treatment of sciatica. Several of our patients were relieved by fasciotomy, either with or without the removal of a herniated nucleus pulposus. I hope that it is understood that all of our cases of sciatica were not explored for herniation of an intervertebral disc. Considerably less than 10 per cent. came to operation. The others were treated conservatively.

An effort has been made to emphasize two points in this paper. The first is the desirability of cooperation between the neurosurgeon and the orthopaedic surgeon in the treatment of sciatica. The second is that there are a certain number of cases of herniation of the nucleus pulposus in which it is advisable to do a spine fusion. In just how many cases this should be done we are not yet sure, but I believe that it is higher than is the practice in most clinics.

THE EPIDEMIOLOGY OF POLIOMYELITIS *†

BY ROBERT WARD, M.D., NEW HAVEN, CONNECTICUT

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Perhaps the best way to begin a discussion of the epidemiology of poliomyelitis is to state that we do not yet know how poliomyelitis is transmitted. Lest I be accused, like one of Conrad's characters, of possessing "that irresistible impulse to impart information which is inseparable from gross ignorance", may I add that our present state of ignorance about the matter is perhaps more salubrious than the complacency with which the problem was regarded a few years ago. In fact, in 1935, there was no problem as to how poliomyelitis was spread, for most felt that the question was all settled on the basis of contact infection. Virus entered and left by way of the nose, and poliomyelitis was placed in the category of respiratory infections, like the common cold, influenza, and so forth. A number of things have come to change our thinking about this question. First and foremost is the fact that poliomyelitis in the North, unlike the respiratory infections, is a *summer epidemic disease*, which strongly suggests something other than direct contact to explain its spread. Recently certain new facts concerning the natural history of poliomyelitis have come to light, which appear to point the way toward a better understanding of the possible mode or modes of transmission; and other findings have been confirmed and extended. These facts relate to the questions of how the virus enters the human body, how it leaves, and where it may be found outside the body.

The *portal of entry* is of obvious importance to the epidemiologist, for it determines whether he looks for the causative agent in droplets of nasal spray, in contaminated food or water, or in contaminated biting insects. Dr. Sabin has presented the evidence derived from tests on human materials, which tends to discount the upper respiratory and particularly the olfactory portal, as playing important rôles in the disease in man.[8] We are left then with two possibilities, the alimentary tract (mouth to colon) and the skin. With respect to the former, Dr. Sabin has shown that virus is distributed in fatal human cases chiefly in two systems,—namely, the alimentary tract and the central nervous system. In the absence of evidence for centrifugal spread of virus from the nervous system to peripheral tissues containing nerve cells of the autonomic nervous system, the finding of virus predominantly in the alimentary tract and central nervous system points to the former as a site of primary attack and invasion.[8]

This evidence, strong as it seems, because it is based on tests on *human* materials, does not preclude the possibility of the skin as a portal of entry. In fact, poliomyelitis has actually been produced in man by the injection of virus under the skin. This occurred accidentally at the time when vaccines were being tried as a prophylactic measure. Furthermore, if one is allowed to draw deductions from the experimental disease—which is dangerous—experiments conducted in the laboratory of the Yale Poliomyelitis Study Unit by Trask, Paul, and Melnick have shown that virus, inoculated into and under the skin of several species of monkeys, was recovered from their stools at or about the time that the experimental disease became manifest, and—of more importance—prior to the onset of fever and prior to the onset of signs in the central nervous system.[4] More work must be done—such as a study of the distribution of virus at various times after intracutaneous and subcutaneous inoculation in various primates—before one can truly evaluate this finding. Caution must be observed always in the transmutation of experimental evidence

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into the human field. At least one is tempted to say that the finding of virus in the stool need not imply that it first entered via the alimentary tract.

Portal of Exit: At present the chief mode of elimination of the virus appears to be by way of the stools. This finding has received particular emphasis in the past few years. In fact, the ease with which virus is detected in the stools is in sharp contrast to the difficulty in detecting it in nasopharyngeal washings.[4] The absence of virus in human nasal secretions and oral secretions indicates: (1) that the nose and mouth are not common portals of elimination of virus, and (2) that virus in the stool does not represent secretions from the nose and mouth that have been swallowed and concentrated in the intestinal tract.[10] * Virus may be found not only in the stools of paralytic patients, but also in those of patients with non-paralytic and abortive types, and even in apparently healthy individuals. The potential epidemiological significance of this is great, and suggests certain analogies with such intestinal infections as typhoid fever and dysentery, although there are certain differences. The question has arisen, do chronic carriers of poliomyelitis virus exist, similar to carriers of typhoid bacillus? The existing data indicate that virus has been commonly found in the second and third weeks of convalescence, occasionally in the fourth and seventh weeks, and in one instance, even as late as the seventeenth week. Further attempts to answer this question, carried out at Yale by Horstmann and Melnick,[17] show a progressive decline, during the first eight weeks of the disease, in the number of convalescent patients excreting virus. From the ninth to the twenty-fourth weeks, virus was found only once—namely, at twelve weeks—in about fifty specimens tested. While the existence of chronic carriers of virus cannot be ruled out by these findings, nevertheless it would appear at least that such do not occur following poliomyelitis with the same frequency (1 to 4 per cent.) that obtains after typhoid fever.

This brings us to the next question,—namely, what happens to virus after it leaves the patient? Where may it be found in nature? Virus has been detected in urban sewage during epidemics twelve times.[4, 17] While this may not seem surprising to some, in view of the remarkable stability of the virus and the large quantities of it which may be found in stools, nevertheless it seems quite startling to me that virus can be picked up in a 200-cubic-centimeter sample of sewage which flows at the rate of 400,000,000 gallons a day. Virus was recovered by Melnick during the 1943 epidemic in Chicago from the *effluent* of one such disposal plant, where treatment accorded the sewage was mild.[17] It should be stressed that we have no evidence for the presence of virus in sewage as constituting a link in the infection chain. On the other hand, it would seem to be equally illogical to dismiss the finding as of *no* significance, because the available evidence points away from poliomyelitis as being a *water-borne* disease. Although it is far from clear how virus may travel, if indeed it ever does, from contaminated sewage to the susceptible human being, one should consider, in addition to water, other agents,—such as certain forms of insect, avian, and mammalian life, which may come into contact with both sewage and man. These are problems for the future, and for the present all one can say is simply that virus is in sewage, and this may well be only as a *resultant* rather than a causal factor in human poliomyelitis.

The second—and at present, only other—extra human source of virus is from flies trapped in epidemic areas.[6, 11, 12, 13, 14, 15] The flies yielding virus were chiefly blowflies (phaenicia sericata), although in some batches the common housefly (musca domestica) predominated. Both species commonly frequent faecal matter. Although this finding has been confirmed in several different epidemics and by different workers, its epidemiological significance remains unknown for the present. Three facts are striking,—namely: (1) Virus was detected not only in flies caught in rural areas close to open privies (obvious sources of contamination), but also in modern urban districts where the source of con-

* Since this paper was presented, Howe and his associates[3] have reported the detection of virus in pharyngeal swabs of seven out of fourteen patients in the first week of illness. While this does not demonstrate the actual elimination of virus from the oropharynx, nevertheless, it serves to keep open the question of transmission in this manner by person-to-person contact.

tamination was not obvious. (2) In one laboratory, virus was demonstrated in eight out of the fifteen batches of flies tested.[11] (This score is about as good as one might expect from tests on human stools during the acute stage of the disease.) (3) The positive results with flies were achieved with one possible exception [13] by inoculating cynomolgus or Java monkeys, no longer obtainable.

In their absence, interesting experiments have been carried out with strains of poliomyelitis virus adapted to the mouse, [1, 7] indicating that virus may persist in the housefly as long as one to two days, and in one experiment, as long as twelve days after ingestion.[1] Virus has also been recovered from the faecal and vomit spots, and from the abdomen of flies, which again suggests a more intimate relationship than if the virus were found merely on the fly's exterior. The final answers to such questions as, "Are flies *infective* as well as contaminated, and does virus actually multiply in the fly host?" must await such time as experimental animals more susceptible than the rhesus monkey are available.

These, then, are the recently discovered facts and the lately confirmed and extended old facts which help to direct our thinking about the natural history of poliomyelitis. In discussing its *manner of spread*, we must step off fairly solid ground into the field of speculation. In the first place, it has become apparent to several observers that poliomyelitis is probably spread in a number of different ways. No one doubts that contact infection occurs in certain outbreaks; but, in many others, infection occurs in the absence of apparent contact. The striking *seasonal incidence* of the disease in this climate, with the epidemic peaks occurring as a rule in the late summer and early fall, are not explained on the basis of contact infection.[4] On the other hand, contact may explain the occurrence of cases of winter poliomyelitis, long suspected on clinical grounds and recently confirmed by detection of virus in cases and in healthy carriers.[16] Poliomyelitis thus exists the year round, and the sharp seasonal peak in summer and fall may be due to factors facilitating the dissemination of virus, such as insects. In fact, the seasonal epidemiology of poliomyelitis is quite similar in some areas to that of the summer mosquito-borne encephalitides, —western equine and St. Louis encephalitis. In the Canadian epidemic of 1941, the two diseases—poliomyelitis and western equine encephalitis—appeared and disappeared in the same areas almost simultaneously.[4] This parallel has occurred also in Kern County, California.[2] No poliomyelitis virus has ever been detected in mosquitoes caught in epidemic areas, although the number of tests is inadequate, especially in regard to the use of the particularly susceptible cynomolgus monkey.

The *geographical distribution* of poliomyelitis is apparently world-wide. Although it has been said that no country is entirely free, the disease seems to be most common in the north and south temperate zones, particularly in Scandinavia, Canada, the United States, Australia, and New Zealand. Recently attention has been called by Paul and associates [5] to the incidence of poliomyelitis in the Mediterranean area as being equal to and, in certain circumstances, greater than the attack rate in this Country, the difference being that, in general, epidemics do not occur in the Middle East. The disease prevails year in, year out, with maximal incidence in the spring and fall. Thus it is suggested that poliomyelitis may occur just as frequently in tropical and semitropical countries, but that, in the latter, the lack of a sharply defined seasonal concentration serves to keep the problem in the background.

To sum up, studies on the natural history of human poliomyelitis provide no support for the belief in the olfactory portal of entry of virus, but do suggest that the entire alimentary tract may provide a site or sites of primary attack and invasion. The skin remains a possible portal of entry. The chief mode of elimination of virus at present appears to be by way of the stools. The striking seasonal incidence, the evidence for the human alimentary tract as a portal of entry, and the finding of abundant virus in stools, sewage, and flies, while not establishing these latter materials as definite links in the infec-

tion chain, nevertheless suggest that poliomyelitis should be placed tentatively in the group of excremental infective diseases, until other modes of spread become established.

REFERENCES

1. Bang, F. B., and Glaser, R. W.: The Persistence of Poliomyelitis Virus in Flies. Am. J. Hygiene, XXXVII, 320, 1943.
2. Buss, W. C., and Howitt, B. F.: Human Equine Encephalomyelitis in Kern County, California, 1938, 1939, and 1940. Am. J. Pub. Health, XXXI, 935, 1941.
3. Howe, H. A.; Wenner, H. A.; Bodian, David; and Maxcy, K. F.: Poliomyelitis Virus in the Human Oro-pharynx. Proc. Soc. Exper. Biol. and Med., LVI, 171, 1944.
4. Paul, J. R.: Poliomyelitis. The Harvey Lecture Series, XXXVIII, 104, Lancaster, Pennsylvania, The Science Press Printing Co., 1942–1943.
5. Paul, J. R.; Havens, W. P., Jr.; Van Rooyen, C. E.: Poliomyelitis in British and American Troops in the Middle East. The Isolation of Virus from Human Faeces. British Med. J., I, 841, 1944.
6. Paul, J. R.; Trask, J. D.; Bishop, M. B.; Melnick, J. L.; and Casey, A. E.: The Detection of Poliomyelitis Virus in Flies. Science, XCIV, 395, 1941.
7. Rendtorff, R. C., and Francis, Thomas, Jr.: Survival of the Lansing Strain of Poliomyelitis Virus in the Common House Fly, *Musca Domestica* L. J. Infectious Diseases, LXXIII, 198, 1943.
8. Sabin, A. B.: Pathology and Pathogenesis of Human Poliomyelitis. J. Am. Med. Assn., CXX, 506, 1942.
9. Sabin, A. B., and Ward, Robert: The Natural History of Human Poliomyelitis. I. Distribution of Virus in Nervous and Non-Nervous Tissues. J. Exper. Med., LXXIII, 771, 1941.
10. Sabin, A. B., and Ward, Robert: The Natural History of Human Poliomyelitis. II. Elimination of the Virus. J. Exper. Med., LXXIV, 519, 1941.
11. Sabin, A. B., and Ward, Robert: Flies as Carriers of Poliomyelitis Virus in Urban Epidemics. Science, XCIV, 590, 1941.
12. Sabin, A. B., and Ward, Robert: Insects and Epidemiology of Poliomyelitis. Science, XCV, 300, 1942.
13. Toomey, J. A.; Takacs, W. S.; and Tischer, L. A.: Poliomyelitis Virus from Flies. Proc. Soc. Exper. Biol. and Med., XLVIII, 637, 1941.
14. Trask, J. D.; Paul, J. R.; and Melnick, J. L.: The Detection of Poliomyelitis Virus in Flies Collected during Epidemics of Poliomyelitis. I. Methods, Results, and Types of Flies Involved. J. Exper. Med., LXXVII, 531, 1943.
15. Trask, J. D.; Paul, J. R.; and Melnick, J. L.: The Detection of Poliomyelitis Virus in Flies Collected during Epidemics of Poliomyelitis. II. Clinical Circumstances under Which Flies Were Collected. J. Exper. Med., LXXVII, 545, 1943.
16. Ward, Robert, and Sabin, A. B.: The Presence of Poliomyelitis Virus in Human Cases and Carriers during the Winter. Yale J. Biol. & Med., XVI, 451, 1944.
17. Yale Poliomyelitis Study Unit: Unpublished Data.

EXTRA-ARTICULAR GRAFT FOR NON-UNION IN COLLES'S FRACTURE

BY DR. GAWAD HAMADA, ALEXANDRIA, EGYPT

Non-union in the lower end of the radius is very rare. Watson-Jones[1] found one case of non-union out of 3,199 fractures. He also refers to 870 cases, treated at Massachusetts General Hospital, where every complication was considered except non-union. However, when the condition presents itself to the surgeon, the method of treatment becomes a problem.

Complete immobilization of the fragments by the various methods known to us is not possible, because it is difficult to fix the small distal radial fragment to the long proximal one. The small distal radial fragment is so near the wrist joint that the slightest movement of the hand affects this bone.

The various operative methods commonly used for non-union of bones are wiring, nailing, stitching, plating, and pegging or grafting. If any of these methods are used, the whole hand below the heads of the metacarpal bones must be immobilized in plaster. This, beyond the fact that it might produce adhesions and stiffness of the fingers, does not completely immobilize the fracture area.

Some method must be found which will not hamper the movements of the fingers, but will immobilize the fragments and firmly fix the joint. The use of an extra-articular graft was found to answer this demand.

OPERATION

An incision, about twelve centimeters in length, is made on the dorsum of the hand from near the middle of the metacarpal bones to about six centimeters above the wrist joint. The wrist joint and dorsal ligament are left untouched. By blunt dissection the abductor pollicis longus and extensor pollicis brevis are retracted outward, while the tendon of the extensor digitorum communis is retracted from over the middle of the metacarpal bone. The fractured ends are denuded of all interposing tissue. The sclerosed ends are removed, and the fragments are apposed to each other. A whole tibial graft, ten centimeters in length and one centimeter in breadth, with its overlying periosteum, is marked out and is removed with an electric saw. Five or six

FIG. 1-A

FIG. 1-B

March 21, 1940. Showing the appearance of wrist when patient was first seen.

holes are drilled through the graft, which is then applied as an onlay graft in the bed previously prepared for it. Holes are made in the two radial fragments and in the metacarpal bone. The graft is fixed by strong catgut, threaded through the holes in the radial fragments. Small chip fragments of bone are packed between the fractured ends.

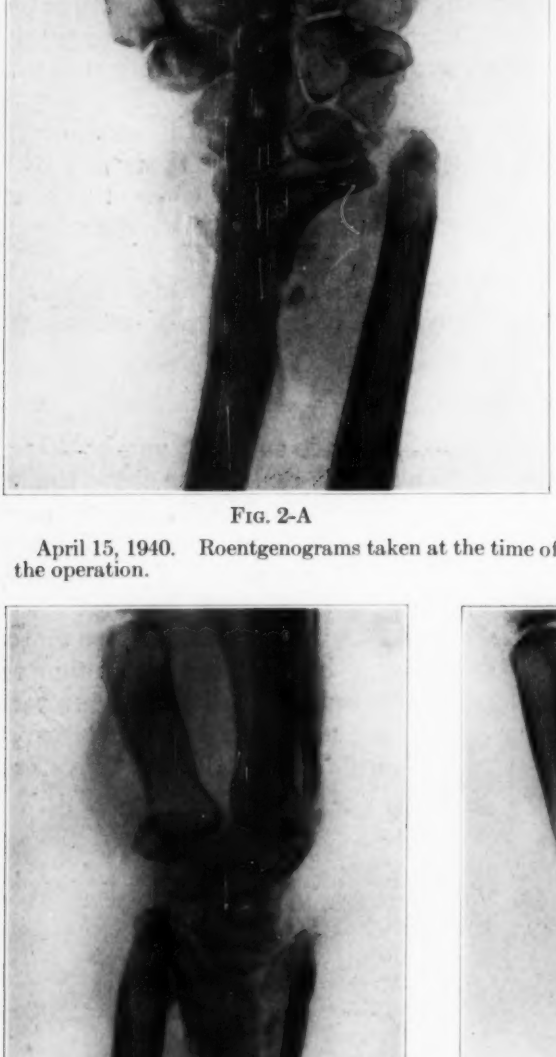

FIG. 2-A

FIG. 2-B

April 15, 1940. Roentgenograms taken at the time of changing the plaster about three weeks after the operation.

FIG. 3-A

FIG. 3-B

September 8, 1940. The extra-articular bridge has been removed; firm union has occurred.

FIG. 4-A

FIG. 4-B

January 5, 1944. Final result.

If there is shortening of the radius, with radial deviation of the hand, the lower end of the ulna should be resected through a small separate incision, and the hand should be straightened before the graft is definitely fixed.

Plaster is applied, extending from the middle of the arm to the head of the metacarpal bones. This allows movement of the fingers and their interphalangeal joints.

Six months later, when union has been confirmed by roentgenogram, a second operation is performed. The graft is severed at the wrist joint, and its distal part is removed. The wrist joint is then tested for movements of flexion and extension, and the wound is closed.

FIG. 4-C

Showing cosmetic result. At this time there was 40 degrees of flexion, and 35 degrees of extension.

DISCUSSION

The case illustrated shows clearly the condition in its different phases of treatment. Four years after operation, the range of active movement of the wrist was 40 degrees of flexion, and 35 degrees of extension. The grip was fairly strong, but the fingers could not be completely flexed. The partial limitation of finger movements was probably due to the fact that the case was one of old septic compound fracture. It will be noticed in the final roentgenogram that the graft has taken part in the formation of the radial mortise.

1. Watson-Jones, R.: Fractures and Other Bone and Joint Injuries. Ed. 2. Edinburgh, D. and S. Livingstone, 1942; and Baltimore, Williams and Wilkins, 1941.

A NEW DEODORIZING PLASTER BANDAGE

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Many attempts involving a variety of approaches have been undertaken to eliminate, or at least to reduce, cast stenches on patients undergoing treatment, with closed plaster, for osteomyelitis and compound fractures. Without attempting to examine them all, the following principles have been employed:

1. Segregating patients in private rooms;
2. Changing casts as frequently as the plaster becomes permeated with odor;
3. Masking the stench with penetrating, aromatic odors,—such as oakum, burned incense, iodoform, or commercial perfumes;
4. Oxidizing the odors with chlorine compounds—such as Dakin's solution or azochloramide—or with zinc peroxide, hydrogen peroxide, sodium perborate, or ozone;
5. Preventing the formation of odor by the introduction into the wound of bacteriophage or sulfonamides, or by dressing the wound with pectin to provide sugar (lactose) for the wound flora, and thus to encourage fermentation and discourage putrefaction of protein;
6. Adsorption of the odor by bags containing activated carbon hung on the patient's bed or pulled over the cast itself.

It is beyond the scope of this paper to evaluate these efforts to solve the odor problem. Aside from the first two or three, none has been widely accepted or used; few comply with the requirement of the problem,—elimination of odor without interference with the primary surgical technique.

Deodorizing Plaster Bandages

A new and better approach to the elimination of odor in osteomyelitis and infected compound fractures would be to adsorb the odor or entrap it in the cast itself. This can be accomplished clinically with casts made of special plaster bandages containing selected activated carbons. The casts have been found to be very efficient in eliminating suppurating-wound odors, without introducing any changes in the primary surgical treatment of the patient, or any new problems in the nursing care. Moreover, there is no interference with the immobilization and protection afforded by the closed-plaster method.

The cast material is made by combining activated carbon and plaster-of-Paris with a binder, to form a cementitious composition which is then applied to crinoline bandages to produce a hard-coat type of plaster bandage. Casts made of this material are gray in color. Upon immersion, these bandages become saturated in three to five seconds. In handling, they appear dirtier, as the plaster is gray instead of white, but the gray plaster washes off the hands and linen as readily as does the white. The presence of carbon tends to change somewhat the setting time of the plaster, but this is controlled in processing by the adjustment of accelerating or retarding agents.

The gray cast has a lower specific gravity and density, and produces a more porous structure, with greater air and fluid permeability. Clinically, it is observed that the customary waxy deposit, seen on the inner surface of regular plaster casts in draining wounds, is not present when deodorizing bandages are used.

Technique of Application

The technique of using gray deodorizing plaster bandages does not differ in any major respect from that of using regular plaster. The bandages hydrate sufficiently rapidly so

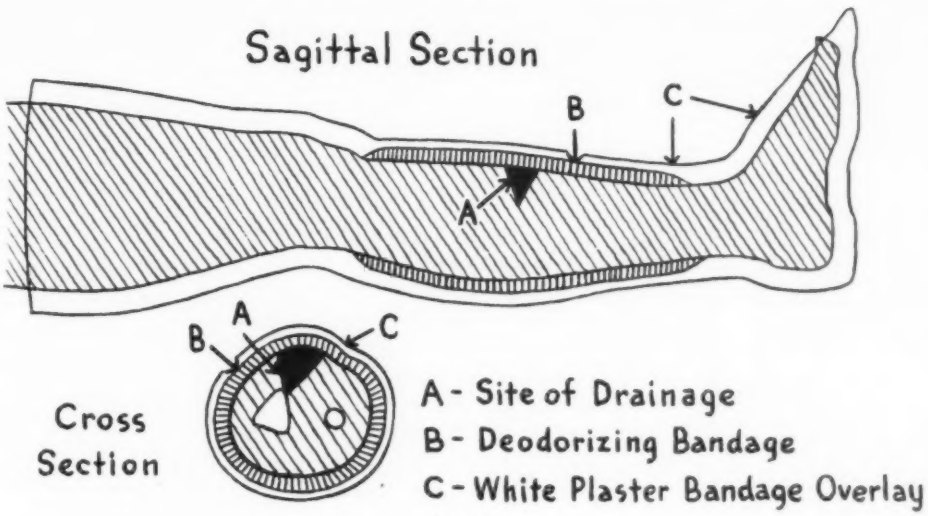

FIG. 1

that, after a few seconds' immersion in water, they are saturated and may be removed for use.

In the preferred procedure, a thin gray cast is made over the entire anticipated drainage area. This is covered with an overlay of ordinary white plaster—comprising two-thirds of the bandages used—which not only covers the gray bandages, but extends above and below the adjacent joints and completes the cast. The finished appearance, then, is that of an ordinary conventional white plaster cast. Cast padding is used at the surgeon's discretion. Figure 1 shows the gray plaster with white bandage overlay.

The advantages of this technique are that the deodorizing gray plaster covers the area where odor arises, and the white plaster completes the cast, giving it the appearance and strength of the conventional plaster cylinder.

SUMMARY

1. Closed casts made of gray deodorizing plaster bandages with an overlay of conventional white plaster bandages effectively eliminate the odor associated with the closed-cast technique.

2. The deodorization is efficiently accomplished by physical adsorption of odor, rather than by chemical destruction. In distinction to most other techniques, this does not interfere with the surgical management of the case.

CONCLUSIONS

1. Clinical experience has demonstrated that the odor of osteomyelitis and infected compound fractures can be eliminated by the use of special gray plaster bandages.

2. The primary surgical treatment is not changed.

3. The capacity of the cast to absorb purulent material is enhanced by its increased porosity.

4. The preferred technique of application maintains strength without increasing the number of bandages used, and preserves the white appearance of the finished cast by applying the conventional white plaster over a base of deodorizing plaster bandages.

DEGENERATIVE CALCIFICATION IN ARTICULAR CARTILAGE OF THE KNEE

Differentiation from Calcification of the Menisci

BY PAUL H. HARMON, PH.D., M.D., SAYRE, PENNSYLVANIA

From the Section on Orthopaedic and Traumatic Surgery, The Guthrie Clinic and The Robert Packer Hospital, Sayre

Recently the author has had occasion to examine the roentgenograms of the knees of two patients, in one of whom the symptoms suggested the diagnosis of degenerative arthritis, in the other, gout. The unique feature of these two cases was calcification within the joint, the distribution of which, while suggestive of calcification or ossification of the menisci, was so located as to definitely rule out these conditions and to place the change in the articular cartilage. A number of reports of calcification and ossification in the menisci have been published during the past ten years, chiefly in the foreign literature; Weaver [1] has summarized this material. However, little has been published on calcification of the articular cartilage. In view of the similarities and yet definite dissimilarities to meniscus calcification, the following case reports may be of interest.

Case 1. G. P., a male, aged seventy-five years, was admitted to the Hospital a month before death, stating that five days prior to admission he had slipped on the ice, striking his left leg on the ground. In spite of fairly severe pain, he was able to limp several blocks to his home. He had had "rheumatism all over" for thirty years, with the special complaint of pain, disability, and intermittent swelling in the left knee, requiring the use of a cane for the past ten years. The clinical findings were consistent with the diagnosis of degenerative arthritis.

Roentgenograms of the left knee showed marked subchondral sclerosis of the medial tibial condyle. The remarkable finding was a narrow intra-articular zone of calcification, which followed exactly the contour of the articular cortex of the femoral condyles into the recesses of the joint; this was seen in both the lateral and the anteroposterior views. (Unfortunately the roentgenograms are not clear enough to be reproduced satisfactorily.) Lipping was present on many of the bony components of the knee joint. Roentgenographic examination of the right knee showed similar osteo-arthritic changes, but very slight calcification.

Treatment of the knee condition was by bed rest, with adhesive-tape extension on the left leg, and by aspiration of both knees. This served to relieve his pain.

The general examination on admission revealed an enlarged prostate, and the heart was in auricular fibrillation. Examination by the urologist confirmed the prostatic enlargement and urinary-tract infection. During the patient's hospital stay, it became impossible to bring this infection under control, and he succumbed to it.

At autopsy, examination of both knees was carried out; the findings in the left knee were of special interest. Gross sectioning of the menisci at short intervals failed to reveal any but extremely light and sporadic yellowish discoloration, indicating small scattered foci of calcification. These were so slight that no shadow was cast when roentgenograms were made of these structures alone. The articular cartilage was entirely missing from the central and contact portions of the medial tibial and femoral condyles, each defect unquestionably being due to advanced degenerative changes at this site. Peripheral to this island of bare bone, the cartilage was gray-yellow. Gross and microscopic sectioning of cartilage in this region demonstrated an advanced state of diffuse calcification. (These slides are no longer available.)

Case 2. E. H., a male, aged fifty-five years, came to the Clinic, giving a history of progressive pain and limitation of motion in the right knee for the previous four days. The joint was diffusely swollen, especially around and above the patella, and there was a considerable increase in synovial fluid. The patient's temperature on admission was 100 degrees; two days later it reached a maximum of 102 degrees, by which time there was similar involvement of the left knee.

Laboratory findings: Examination of the blood was normal, with 9,800 leukocytes per cubic millimeter. Three successive examinations for uric acid in the blood showed 6.7, 7.6, and 10.0 milligrams per 100 cubic centimeters. Other blood determinations were: urea nitrogen 19.0 milligrams, fasting blood sugar 132.0 milligrams, calcium 10.4 milligrams, and phosphorus 2.5 milligrams per 100 cubic centimeters. The erythrocyte sedimentation rate was 21.0 millimeters in one hour (Cutler-tube method).

The diagnosis was gout.

FIG. 1-A

FIG. 1-B

Anteroposterior and lateral views of right knee on admission.

FIG. 2-A

FIG. 2-B

Anteroposterior and lateral views of left knee a few days after admission.

Roentgenographic examination showed similar findings in both knees. The only positive findings in these films, other than the soft-tissue thickening, were those of a very definite and extensive linear zone of calcification, which followed the contour of the femoral condyles, in both the anteroposterior and the lateral views of both knees (Figs. 1-A, 1-B, 2-A, and 2-B), there being little difference in the extent of the changes between the two joints. Roentgenographic examination of other joints demonstrated the same type of change in both wrists (Fig. 3).

Treatment of the patient was by colchicine and by extension on the right lower leg (applied with adhesive tape), bed rest, and compression of both knees by elastic bandages. Aspiration of the right knee yielded sixty cubic centimeters of yellow, slightly clouded synovial fluid. Microscopic examination of

FIG. 3

Similar changes were evident in the wrist joints.

aspirated fluid showed a moderate number of polymorphonuclear neutrophil leukocytes. Cultures for bacteria were sterile.

The final diagnosis was calcification in the articular cartilage (multiple joints) and exacerbation of gout.

Roentgenographic observations of this patient's joints have been made recently, two years after the acute phase; there is now a slight extension of the calcification.

DISCUSSION

The findings of calcification in the articular cartilage in both cases described in this report were incidental, during roentgenographic examination for trauma to the knee in one patient, suffering from multiple degenerative arthritis, and for an acute attack of gout in the other. The connection between the two conditions in the latter patient is purely incidental, inasmuch as there was no evidence in the roentgenograms of the usual alterations of the bones by deposits of uric acid.

A description of dense calcification of the articular cartilage, sufficient to cast a shadow in the roentgenograms, is not found elsewhere in the literature, and for that reason it is hoped that the report of these two cases will stimulate similar observations on other patients. No treatment was indicated in either of these cases, as the condition which caused acute symptoms in each case was apparently unrelated to the calcification of the articular cartilages.

The importance of these cases lies in the differentiation of this condition from calcification of the menisci. The exact incidence of roentgenographically demonstrable calcification of articular cartilage is unknown, but it is thought to be more rare than calcification of the meniscus.

1. WEAVER, J. B.: Calcification and Ossification of the Menisci. J. Bone and Joint Surg., XXIV, 873, Oct. 1942.

News Notes

The **American College of Surgeons,** upon action of its Board of Regents, has cancelled its Annual Clinical Congress, because of the acute war situation that has developed, involving greater demands upon transportation systems for the carrying of wounded military personnel, troops, and war material. The Congress was to have been held in Chicago, October 24 to 27.

The **International College of Surgeons** is holding its Ninth Annual Assembly at the Benjamin Franklin Hotel in Philadelphia, Pennsylvania, October 3, 4, and 5, 1944. This Assembly is sponsored by the United States Chapter, Thomas A. Shallow, M.D., F.A.C.S., F.I.C.S., President. Dr. Rudolph Jaeger is General Chairman of the Arrangements Committee. The program is devoted to war, rehabilitation, and civilian surgery.

THE INTER-AMERICAN ORTHOPAEDIC FELLOWSHIP PROGRAM

Fellowships in Orthopaedic Surgery in the United States are now available to male citizens of the Latin-American Republics. Announcement to this effect has recently been made in a pamphlet entitled "Inter-American Orthopaedic Fellowship Program", which is now being distributed by the Institute of International Education, and the United States Department of State through the Cultural Relations offices of our Embassies in those countries.

In the Program is outlined the purpose, scope, general schedule of training, and the financial arrangements of the plan. The qualifications for eligibility, the method of selection of Fellows, and the procedure are explained.

Each Fellowship provides a residency for a period of twelve months in a well-recognized orthopaedic teaching center, where the Fellow will receive basic and advanced training according to his needs. In addition, he will have field experience, including possible attendance at an annual meeting of the orthopaedic surgeons of this Country, and at least one week under the direction of the W. K. Kellogg Foundation, with opportunity to study comprehensive state-wide programs for the care of crippled children in Michigan and other States. The Fellowships may be renewed under certain conditions, for a period up to one year.

The selection of suitable candidates is made by Committees of Selection in each country, of which the recommending Professor of Orthopaedic Surgery or other prominent orthopaedic surgeon becomes an *ad hoc* member. These Committees, created by the Institute of International Education, have been functioning for a number of years. Their work is carried on in concert with the Cultural Relations Divisions of the United States Embassies. Candidates are approved by the Committee on Inter-American Fellowships in Orthopaedic Surgery and the W. K. Kellogg Foundation. Fellowships are awarded to deserving students of the specialty who shall have graduated from recognized medical schools and completed one year of internship.

Fellowships are adequately financed (including travelling expenses).

Counsel is provided whereby the Fellow may best prepare himself for his sojourn in the United States: may be assigned to that orthopaedic center most suited to his needs; and his program so arranged that he may be best fitted for the responsibilities he is to assume on returning to his native country.

The Fellowship Program is sponsored by The American Academy of Orthopaedic Surgeons and The American Orthopaedic Association (each acting through the joint committee appointed by them and designated the Committee on Inter-American Fellowships in Orthopaedic Surgery), in cooperation with the Institute of International Education, the United States Department of State, the W. K. Kellogg Foundation, and various orthopaedic training centers.

The purpose of these Fellowships is two-fold: the advancement of orthopaedic surgery through training and exchange of knowledge in this field; and the development of a deeper understanding and hence closer friendship between the American Republics.

It is the earnest hope of orthopaedic surgeons in the United States that these Fellowships may be the means of strengthening the bonds of friendship already existing among members of our profession throughout the Americas, and that an equally warm welcome will await advanced students of orthopaedic surgery from the United States who wish to avail themselves of the rich experience of study in the Latin-American centers of learning and culture.

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Thirteenth Annual Convention of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, January 21–24, 1945, under the presidency of Dr. E. Bishop Mumford. A program of unusual interest has been prepared by the Program Committee of which Dr. Robert W. Johnson, Jr., is Chairman. Details of the program will be announced in the next issue of *The Journal*.

SCHEDULE OF INSTRUCTIONAL COURSES FOR THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS
SUNDAY, JANUARY 21, 1945

Time	Subject and Lecturer	Subject and Lecturer	Subject and Lecturer	Subject and Lecturer	Subject and Lecturer
9:00 A.M. to 9:50 A.M.	I. Treatment of infantile paralysis *Ralph K. Ghormley*	I. Knee,—orthopaedic anatomy *J. B. deC. M. Saunders* and *LeRoy C. Abbott*	Cerebral palsies *Winthrop M. Phelps*	Club feet *J. H. Kite*	I. Physiology of bone *C. H. Hatcher*
10:10 A.M. to 11:00 A.M.	II. Treatment of infantile paralysis *William T. Green*	II. Knee,—clinical application *J. B. deC. M. Saunders* and *LeRoy C. Abbott*	Posture *F. A. Jostes*	Fractures of the shaft of the femur *Guy Caldwell*	II. Physiology of nerves *E. L. Compere*
11:20 A.M. to 12:10 P.M.	I. Foot and ankle,—symptoms, pathology, and diagnoses *Lenox Baker*	III. Knee,—treatment of disease *A. F. Voshell*	I. Hip,—orthopaedic anatomy *J. B. deC. M. Saunders* and *LeRoy C. Abbott*	I. Shoulder,—treatment of disease *David M. Bosworth*	III. Physiology of muscles *Eben J. Carey*
12:10 to 2:00					
2:00 P.M. to 2:50 P.M.	II. Foot and ankle,—orthopaedic anatomy *T. A. Willis*	IV. Knee,—treatment of trauma *J. R. Cobb*	II. Hip,—clinical application *J. B. deC. M. Saunders* and *LeRoy C. Abbott*	II. Shoulder,—treatment of trauma *H. L. McLaughlin*	IV. Physiology of joints *Granville Bennett*
3:10 P.M. to 4:00 P.M.	III. Foot and ankle,—treatment of disease *J. Warren White*	Basic fracture management *J. Albert Key*	III. Hip,—treatment of disease *Alan DeF. Smith*	III. Shoulder,—orthopaedic anatomy *J. B. deC. M. Saunders* and *Frederic C. Bost*	I. Orthopaedic x-ray of the upper extremity and neck *S. A. Morton*
4:20 P.M. to 5:10 P.M.	IV. Foot and ankle,—treatment of trauma *Harry Winkler*	Conservative treatment of low-back syndrome *E. M. Regen*	IV. Hip,—treatment of trauma *Lawson Thornton*	IV. Shoulder,—clinical application *J. B. deC. M. Saunders* and *Frederic C. Bost*	II. Orthopaedic x-ray of the lower extremity and spine *S. A. Morton*

The schedule of the Instructional Courses to be given preceding the 1945 Academy meeting has been completed by the Sub-Program Committee, and is as follows: *

Saturday, January 20

10:00 A.M. Registration.
2:00 P.M. to 5:00 P.M. Motion Pictures. (Program to be announced later.)
7:00 P.M. to 10:30 P.M. Instructional Course Dinner.
The Faculty and Executive Committee will be guests.
Following the dinner there will be a Panel Discussion of orthopaedic reconstruction problems and knee derangements.

Sunday, January 21

9:00 A.M. to 5:10 P.M. Courses (see page 842.)

Monday, January 22

9:30 A.M. to 12:00 M	Symposium on Degenerative Hip Pathology.	
	Etiology and Pathology.	Dallas B. Phemister, M.D.
	Conservative Treatment.	P. C. Colonna, M.D.
	Drilling and McMurray Operation.	Murray Meekison, M.D.
	Fusion.	G. E. Haggart, M.D.
	Arthoplasty.	Carl E. Badgley, M.D.
	Summary.	M. S. Henderson, M.D.

It should be noted: (1) that the time allotted for the courses (Sunday, January 21) has been most economically used, in that the teaching periods are limited to one hour; (2) that the subject material is of a fundamental nature, such as orthopaedic anatomy, physiology, and pathology; (3) that the subjects are such that they can be repeated profitably, amplified, and improved in future meetings; and (4) that the various subjects are to be considered from an anatomical and regional point of view. The courses to be given this year will be on the shoulder, the hip, the knee, and the foot. The first period of each will consist of the orthopaedic anatomy; the second, the practical application from the standpoint of symptoms and pathology; the third, the treatment of disease occurring in each one of these regions; and the fourth, the treatment of traumatic conditions. It is hoped that in this way a full and complete survey of each of the subjects can be given with a fundamental anatomical, surgical, and pathological background.

There will be four courses in physiology,—devoted to bone, nerves, muscles, and joints, respectively, as they pertain to various phases of orthopaedic surgery. These should prove extremely enlightening to those who wish to add to their knowledge of these fundamental subjects.

Courses will also be given on infantile paralysis, spastic paralysis, fractures, and interpretation of roentgenograms in orthopaedic surgery.

This year there will be only one lecturer at each period. He will, in the hour allotted, cover as much of the subject assigned as possible.

In addition to the three-hour program of excellent motion pictures scheduled for the afternoon of Saturday, January 20, there will be presented, each morning, an hour of scientific motion pictures, preceding the morning session.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Spring Meeting of The British Orthopaedic Association was held at Leeds, May 12 and 13, under the presidency of Mr. St. J. D. Buxton.

Major R. H. Metcalfe, Royal Army Medical Corps, presented a study of two large series of cases in consecutive years in the same military hospital. In 1942, of 600 patients seen in out-patient departments for injuries to the cartilage of the knee, 100 were admitted to the wards, and of these sixty were operated upon. In 1943, 800 patients were seen; 170 were admitted; and there were 100 operations. An accurate follow-up of these patients was possible through the Army system of medical categorization. During the first year, the average time off duty for those operated upon was nine weeks. In estimating the end results, the men

* Announcement at this early date is made to give to members an opportunity to make a selection of courses best suited to their needs. It is urged that upon receipt of the registration blank, it be filled out and returned as soon as possible. The number who may register for each Course is to be limited.

were placed in the following categories: *A*, 60 per cent.; *B*, 28 per cent.; *C*, 8 per cent.; and *E*, 4 per cent. (Category *C* denotes a man with a severe defect of locomotion, unfit for service overseas, and *E* means discharge from the Army.) The most common cause of a bad result was abnormal anteroposterior mobility, not, in most cases, the result of operation; less common causes were osteochondritis and osteo-arthritis. The question of military morale undoubtedly affected the result. The first year's results suggested that "rehabilitation" had been too vigorous, and had tended to arouse latent anxiety. In 1943, a more stringent physical and psychological selection of patients for operation was made; and less vigorous after-treatment was given, with a shorter period off duty. By getting the soldier back to his unit within the permitted period of three weeks before being "Y" listed, the best results were obtained. This was possible in 20 per cent. of the patients operated upon in 1943, and their present categories are *A*, 81 per cent.; *B*, 14 per cent.; *C*, 5 per cent.; none have been discharged. For the entire 1943 series, the end results are *A*, 71.5 per cent.; *B*, 20.5 per cent.; *C*, 7 per cent.; and *E*, 1 per cent.

Major General D. C. Monro emphasized the recognition of the morale of the military unit as a factor in the recovery from knee and other injuries. Brigadier W. R. Bristow indicated the need for improved treatment of knee injuries, as is shown by the figures of 1,058 patients operated upon in Army and E.M.S. hospitals in 1943. The categories of these patients are *A*, 51 per cent.; *B*, 35 per cent.; *C*, 9 per cent.; and *E*, 5 per cent.

Major J. Stewart, United States Medical Corps, discussed fracture of the carpal scaphoid, which he stated is the most commonly undiagnosed fracture, and urged the need for multiple roentgenograms in doubtful cases. Difficulties have been experienced in distinguishing new from old fractures, and in estimating the nature of vascular changes as a guide to prognosis. In a series of 205 cases, treated within fifteen months, end results are available in 134; 129 patients had been treated in plaster alone, and of these 127 had full union and mobility, freedom from pain, and full grip, and had returned to full duty. The procedure includes immobilization in plaster, extending from the base of the thumb nail, the proximal palmar crease, and the heads of the metacarpals dorsally, to within an inch of the elbow joint, with the wrist dorsiflexed 10 to 15 degrees, but with no lateral deviation. During the application of plaster, the thumb and fingers are held as though grasping a football. This allows full mobility of the fingers afterward, and almost normal activity of the hand. The period of recovery after the removal of the plaster is greatly shortened (three or four weeks). The plaster is changed every three or four weeks, and the fracture is checked roentgenographically, care being taken to prevent movement of the wrist and thumb. This report showed that with early diagnosis, accurate reduction, and adequate immobilization for a sufficient period, solid bony union (in an average of eleven weeks) can be expected. Loss of Army man power, due to delay in union, was directly attributable to failure to observe these principles. Every sprain or injury in the region of the carpal scaphoid should be considered a fracture, until proved otherwise. In patients coming late for treatment, the time of recovery was prolonged; but, with long-continued fixation, provided the proximal fragment is viable, neither vacuolation nor sclerosis at the site of fracture need be regarded as impairing recovery.

From over 100 cases of march fracture of the metatarsals, Captain E. Wynne Jones, Royal Army Medical Corps, found that the incidence of march fracture among Army recruits was 2.8 per cent., and that the fractures occurred toward the end of recruit training in men generally of poor physique and posture, with long, narrow feet, in whom there had been mechanical overloading of the metatarsals. By more careful gradation of route marches for the young recruits, the incidence of fractures had been reduced to 0.9 per cent. Immobilization in plaster gave satisfactory results, but a simpler and more time-saving method was a metatarsal pad applied to the foot with adhesive strapping, and worn with Army boots throughout treatment. Modified training, including everything except road work, running, jumping, and obstacle-course work, is begun immediately, and is continued until all tenderness has disappeared (an average of twenty-one days).

Lieutenant Colonel R. Glen Spurling, United States Medical Corps, described the use of finely drawn tantalum wire for nerve suture, and of tantalum foil as an enclosing sheath at the line of junction to prevent adhesions. This metal, besides possessing qualities of malleability and tensile strength, is, he said, completely inert in living tissues.

Captain D. Killoran, United States Medical Corps, discussed a method of "Coagulum Contact Skin-Grafting", similar to that employed by Sano of Philadelphia, but with modifications necessitated by the lack of heparin. Plasma and a leukocyte cream were prepared from oxalated blood; the plasma was applied to recipient areas and the cream was painted on the deep surface of the graft. This procedure had been adopted for battle wounds a few days after initial débridement, when there was no other means of closing a large skin defect. After grafting, the limbs were immobilized, but pressure dressings were not applied.

Lieutenant Colonel Bricker, United States Medical Corps, doubted how far such a coagulum glue could replace suture and pressure fixation of the graft. Grafts should not be washed in saline before application, because this removes natural adhesive.

Prof. A. Durward of the Leeds School described his researches into "Blood Supply of Nerves", confirming the importance of the longitudinally disposed intraneural vessels, which freely anastomose and convey blood for long distances within nerves, even after division of the many small vasa nervorum which enter laterally.

Prof. M. J. Stewart, speaking on the characteristic histology of "Benign Giant-Celled Synovioma of Tendon Sheaths", said that the intracellular presence of hemosiderin or of lipoids, was merely a demonstration of phagocytosis by the polymorphous connective-tissue cells of which the tumor was composed. The presence of foam cells did not justify the description of certain tumors as "xanthomata". The "xanthic" reaction, wherever seen, was a local phagocytic response by connective-tissue cells to the chemical conditions of their surroundings.

Mr. A. S. Johnstone considered the work of Batson of Philadelphia on the "Vertebral Venous System as a Mechanism for the Spread of Metastases" and reported his own investigations on the subject. There is a freer connection than is commonly recognized between the veins of the prostate and those of the vertebral column, and the vertebral venous system may provide a means for some of the occasional spread from this and other organs, but it by no means accounts for the spread of cancer by the classical means already accepted.

Dr. J. R. Nuttall gave the results of "Treatment of Osteo-Arthritis by Deep X-Ray Therapy" in 259 cases, of which 164 were followed up. There had been no particular selection of cases for treatment. Three months after the completion of treatment, seventeen patients had complete relief of pain, ninety had incomplete relief, and fifty-seven received no benefit. Smaller joints seemed to show the best results. A second course of treatment sometimes gave more relief than the first one.

Mr. L. N. Pyrah reviewed ten cases of "Generalized Osteitis Fibrosa". Six of these patients had been admitted for spontaneous fracture; all ten were found to have parathyroid tumors, which he removed. In making his diagnoses, reliance was placed entirely on blood-calcium and phosphorus estimation, except in one case in which calcium-balance experiments were carried out. The blood-calcium figures ranged from 12.5 to 20 milligrams per 100 cubic centimeters, and the blood phosphorous in every case was low, usually 2 to 2.5 milligrams per 100 cubic centimeters. The plasma phosphatase was raised in every case. Errors in chemical technique vitiated some results.

Mr. Reginald Broomhead and his associates demonstrated a series of orthopaedic cases, including a group of patients who had been operated upon for intractable metatarsalgia with good results. The shaft and head of the metatarsal were denuded; and, after being osteotomized near its base, the metatarsal was rotated through 180 degrees.

At this Spring Meeting the following were elected Associate Members of **The British Orthopaedic Association:**

Mr. J. F. Curr, 26 Inverleith Row, Edinburgh 4, Scotland
Mr. J. Dobson, Wrightington Hospital, Appley Bridge, nr. Wigan, England
Mr. G. N. Golden, Poynings, Haslemere, Surrey, England
Mr. G. Blundell Jones, Eye View, Bramford, Speke, nr. Exeter, Devon., England
Mr. W. Lamont, 29 Raikes Parade, Blackpool, England
Mr. A. J. McCreadie, 20 Carr Road, Nelson, England
Mr. G. M. Muller, (address deleted by censor)
Group-Capt. C. J. S. O'Malley, R.A.F. Rehabilitation Centre, Loughborough, England
Major William Parke, R.A.M.C., 4 Erylmore Road, Liverpool 18, England
Mr. Harold Petty, Leeds General Infirmary, Leeds, England
Mr. R. Roaf, Brentwood, South Road, Grassendale Park, Liverpool 19, England
Mr. A. Singer, Old Church County Hospital, Romford, Essex, England
Lt. Col. A. S. Wesson, Adviser in Physical Medicine, B.N.A.F.
Mr. R. B. Zachary, Wingfield-Morris Hospital, Oxford, England
Mr. Neil Beaton, Ministry of Pensions Atlantic Hospital, Newquay, Cornwall
Dr. Jeanne M. Edwards, Royal Infirmary, Manchester
Mr. Harold A. H. Harris, Southborough House, Chelmsford, Essex
Major E. A. Jack, Balmeanach, Barnshot Road, Colinton, Edinburgh 13, Scotland
Mr. G. S. Janda, Emergency Hospital, Whittingham, Preston
Lt. Cdr. Charles Pearson, R.N., c/o Admiralty (Medical Dept.), London, S. W. 1
Miss Eugenie L. Willis, Royal Infirmary, Manchester

As *The Journal* goes to press, word has been received of the death of Dr. Michael Hoke, at Beaufort, South Carolina, on September 25. A more extended notice will be included in the January issue.

Current Literature

THE RADIOLOGY OF BONES AND JOINTS. James F. Brailsford, M.D., Ph.D., F.R.C.P., F.R.C.S. Ed. 3. Baltimore, The Williams and Wilkins Company, 1944. $12.00.

The third edition of Dr. Brailsford's book, which represents an analysis of his work during the past twenty-five years, is particularly valuable for its comprehensive pictures of characteristic bone lesions. Some patients have been studied by the author throughout the entire twenty-five-year period, and a complete description, therefore, is possible of the onset, development, and pathological changes in these cases.

The importance of frequent roentgenographic examinations is stressed, especially in diseases where sudden changes may be expected. Most lesions of bones and joints follow a general pattern, and anticipated developments are checked easily by roentgenograms.

Attention is paid to the interrelationship of trauma, the osseous dystrophies, tuberculosis, syphilis, and neoplasms.

The entire bony structure is considered, with a discussion of lesions peculiar to each region. Excellent roentgenograms add emphasis and clarity to the author's presentation of material. The effect of soft tissues, which may obscure or confuse the roentgenographic appearance of underlying structures, is mentioned. Correct diagnoses of lesions and subsequent treatment depend upon an accurate interpretation of roentgenograms.

The effect of radiation therapy upon tumors, and its use in angiomata, Hodgkin's disease, mastoiditis, psoriasis, and xanthomatosis are described.

The full bibliography and complete index make this work valuable for reference.

THE ART OF ANESTHESIA. Paluel J. Flagg, M.D. Ed. 7. Philadelphia, J. B. Lippincott Company, 1944. $6.00.

This is the seventh edition of a work which has become a classic in the literature of clinical anaesthesia. The main emphasis is upon inhalation anaesthesia, with particular reference to the administration of ether. The definite description of details of various techniques of administration, accompanied by numerous photographs and diagrams, is especially helpful. The author has made notable contributions to the development of, and the technique for, endotracheal anaesthesia, and there is a generous section describing this method.

To this edition, four short chapters have been added, two of which outline briefly the methods for continuous spinal and continuous caudal anaesthesia. Changes in the remainder of the book are few, and consist in slight additions to the text, the substitution of new illustrations, and the addition of a number of footnotes.

In the opinion of this reviewer, recent advances in physiology and pharmacology, as well as the newer types and methods of anaesthesia, are inadequately discussed. Dealing as it does with the "art" of anaesthesia, the book is extremely valuable; but one must go elsewhere to find a discussion of many matters fundamental in modern anaesthesiology.

THE MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Sir Henry Tidy, K.B.E., M.A., M.D. (Oxon.), F.R.C.P., and A. Rendle Short, M.D., B.S., B.Sc., F.R.C.S., Editors. Bristol, John Wright & Sons, Ltd., and Baltimore, The Williams and Wilkins Company, 1944.

Apparently, just as "There'll always be an England", there will always be a British Medical Annual. For each year, come Axis bombers or robot bombs to England, the Medical Annual continues to appear. The physicians who contributed to the 1944 edition deserve special tribute for the excellent articles which they furnished under such trying circumstances. The value to the profession of this annual review of medical and surgical progress is shown by the advance orders which already exceed those for the last volume.

The present edition comprises 404 pages, with forty plates, and a general index of references. The articles of the forty-one contributors review all the new contributions in medicine and surgery during the past year. It is not possible to enumerate here the many excellent articles contained in the book. It is enough to mention that they cover the field, are brief and concise, and will prove of great value to the busy physician as a quick and useful reference upon almost any problem in which he may be interested.

AN ATLAS OF ANATOMY (In One Volume). J. C. Boileau Grant, M.C., M.B., Ch.B., F.R.C.S. (Edin.). Baltimore, The Williams and Wilkins Company, 1943. $10.00.

This excellent Anatomy, previously published in two volumes, is now presented in one volume. The structures of the human body are shown, region by region, in the usual order followed by the dissector.

Color highlights important features of the illustrations, which are drawn from actual photographs of posed specimens; pertinent observations supplement the legends.

The student or doctor will find this compact reference volume of real value in his study or practice.

TECHNIC OF ELECTROTHERAPY AND ITS PHYSICAL AND PHYSIOLOGICAL BASIS. Stafford L. Osborne, Ph.D., and Harold J. Holmquest, B.S. Springfield, Illinois, Charles C. Thomas, 1944. $7.50.

The subject matter of this book is based upon the courses in electrotherapy given for physicians, medical students, and technicians at the Northwestern University Medical School. It is divided into four sections, covering the subjects of direct current; muscle-stimulating currents; radiation by ultraviolet, visible, and infra-red energy; and high-frequency currents, including their use in artificial-fever therapy. The material is presented clearly and in a style suitable for elementary students in the subject. Laboratory experiments are outlined and discussed. For the more advanced students, the highly technical and mathematical aspects of electrical currents appear in footnotes, which can be omitted, if desired, without interfering with the reading of the text.

A noteworthy feature is the detail with which techniques of application are described. The book is well illustrated with 240 figures and seventy-two tables. It is an excellent supplement to present textbooks of physical medicine, and should be very useful in training specialists and technicians in this field. For physicians and surgeons, this will serve as a valuable reference work, as only well-documented material is presented.

PHYSICAL MEDICINE IN GENERAL PRACTICE. William Bierman, M.D. New York, Paul B. Hoeber, Inc., 1944. $7.50.

Dr. William Bierman's "Physical Medicine", published by Paul B. Hoeber, Inc., 1944, is an up-to-date book. Within its 586 pages the author attempts to cover the entire subject of physical therapy, including a chapter on occupational therapy.

The book begins with the definition of the various physical agencies responsible for, and the physiological responses involved in, vasoconstriction and vasodilation, with a comparative summary of the chief effects of heat and cold upon the human body. Different types of baths are illustrated and their physiological reactions are discussed.

The next few chapters describe visible and invisible radiant heat, and include a schematic chart of a section of skin, illustrating penetration, absorption, and reflection to the lower levels of the skin.

The technique of local and general conversive heating by means of diathermy includes a simple alternating current. The resistance of the various human tissues is shown in a table and measured in ohmage. Short wave of the undamped oscillations is demonstrated by a schematic diagram of a simple, tube-oscillator circuit type, which illustrates how the mechanism of the short wave circuit differs from diathermy. The difference in the development of heat in the various tissues of the living human body between diathermy and short wave is mainly that of more uniformity in creative heat in short wave. Another advantage pointed out is that the application in short wave does not require direct contact as in diathermy. Plates showing various types of flexible electrodes, plates, coils, and orificial electrodes follow the text.

The physiological changes produced by fever therapy are painstakingly explained,—such as those in the cardiovascular and the respiratory systems. The preparation of the patient, technique employed, stages of temperature maintenance, reactions, indications, and possible complications and precautions are also discussed.

The technique of surgical diathermy includes electrodessication, electrocoagulation, and the histological changes occurring within the tissues when electrocoagulation is used. Accompanying this is a table of pathological conditions which shows how the use of the cutting current is of great advantage in surgery.

The chapter on direct or so-called galvanic current includes a discussion on the physics, current dosage, polarity, and sources of supply from which this current is derived. Both electrodiagnosis and treatment by means of the direct current are discussed. This is followed by a picture of a Schnee bath with a four-cell battery attached.

Iontophoresis is explained from a chemotherapy approach. The introduction of salines, histamine, and mecholyl, are discussed, along with other selected drugs of positive or negative affinity in conditions of pain, ulcers, *et cetera*.

The physiology of massage and exercise is discussed, and this is accompanied by group classification and prescriptions. Muscle re-education with pictures which demonstrate assistive and resistive exercises belong in this re-educational branch. Good body mechanics are illustrated by pictures which show relaxation of the body as a prelude to postural training and deep chest breathing. Both functional and structural scolioses and their treatment by prescribed exercise and cast are discussed. Stress is laid upon disorders of the feet. Special emphasis is placed upon prescribed exercise for diabetic patients and those suffering from inguinal hernia.

One entire chapter is devoted to occupational therapy, classified as divertional and restorative activities. A list of subjects is presented, which incorporates those required in training schools for occupational therapy. Lists of crafts are tabulated which facilitate more normal angles of motion of the different joints of the upper and lower extremities.

The chapter headed "Diseases of the Locomotor System" covers treatment by the use of various agencies of physical therapy, the high frequency current, the immersion bath, fever therapy, and massage. Colon irrigation is prescribed for arthritis, fibrositis, and for myogelosis. This may be accompanied by very gentle massage and exercises. Physiotherapeutic measures used in the most desirable combination for the treatment of tenosynovitis, bursitis, and contractures are discussed, as well as refrigeration in the treatment of fractures.

The different forms of paralysis are presented: cerebral palsy, lesions of the spinal cord, and traumatic injuries of the lower motor nerves. The Kenny concept of muscle spasm and incoordination in poliomyelitis is explained, as well as treatment by means of hot fomentations and exercise.

At the end of each chapter there is a list of references. An appendix of twenty pages includes the specifications for equipment in physical therapy departments as used in the New York City hospitals.

The book is to be well recommended. It is adequately indexed, and leaves the student, physiotherapist, or doctor of medicine with an all-embracing outlook on this branch of medicine.

SPONDYLOLISTHESIS. ANALYSIS OF FIFTY-NINE CONSECUTIVE CASES. Guy A. Caldwell. *Annals of Surgery*, CXIX, 485, 1944.

Low-back pain may result from a defect in the neural arch even though slipping cannot be demonstrated. On the other hand, such defects may not cause symptoms, even though marked slipping is present. Because of these variations, it is difficult to evaluate the effects of treatment.

In none of the series of fifty-nine cases was the displacement sufficient to permit its presence to be determined by inspection or palpation. The diagnosis, therefore, depends upon roentgenological examination, unless the deformity is great. Three views are recommended: (1) a direct anteroposterior; (2) a true lateral focussed on the fifth lumbar vertebra; and (3) an anteroposterior view of 35 degrees, with the rays directed toward the head and centered between the sacrum and the fifth lumbar vertebra.

The major displacement is found to take place at an undetermined age, but it seldom occurs in adult life. It is believed that further slipping does not explain the symptoms which probably result from progressive narrowing of the disc space, and from proliferation of bone in the vicinity of the intervertebral foramina. In middle-aged persons not engaged in heavy labor, the symptoms usually are relieved by back supports, physical therapy, and postural exercises. Younger patients may require operative fusion, but it probably would suffice to confine the area of fusion to the lumbosacral articulations. When sciatic pain is associated with spondylolisthesis, the nerve roots should be decompressed, either by removal of the incarcerating bone or by the removal of a protruding disc. Theoretically, it might be best in certain cases to remove the neural arch and the inferior articular processes. Liberation of nerve roots without fusion of the articulation or bridging of the defect is to be supplemented by low-back support and postural exercises.

—Paul P. Swett, M.D., Bloomfield, Connecticut.

DIFFERENTIAL DIAGNOSIS OF CAUSES OF PAIN IN THE LOWER BACK ACCOMPANIED BY SCIATIC PAIN. Paul B. Magnuson. *Annals of Surgery*, CXIX, 878, 1944.

AN ANATOMIC STUDY OF THE LUMBOSACRAL REGION IN RELATION TO LOW BACK PAIN AND SCIATICA. William A. Larmon. *Annals of Surgery*, CXIX, 892, 1944.

These two articles direct attention away from the intervertebral disc and toward the vast potentialities in the intervertebral foramina as the frequent cause of low-back pain and sciatica. While neither communication presents new facts, they combine to serve a splendid purpose in bringing forcibly to clinical attention a much needed perspective on this problem. They also provide renewed assurance that the time has not come when it is necessary to abandon all previous concepts about the back in favor of the intervertebral-disc theory. Larmon dissected ten unpreserved and unselected spines at autopsies to determine the factors which may produce compression or irritation of the spinal nerves in the intervertebral foramina. Four anatomical and pathological factors produced compression of the spinal nerve roots: (1) posterior lipping of the vertebral bodies; (2) anomalies of the first sacral body; (3) narrowing of the intervertebral foramen due to collapse of the disc; and (4) variations in ligamentous structures adjacent to the fifth lumbar foramen.

Magnuson believes that pain after an injury to the low back frequently is connected with injury to the ligaments and joints, which is associated with swelling. This may be caused by minor strains of ligaments or joints already degenerated, or by lack of bony support due to malformations. It is noteworthy that degeneration of a disc not only reduces the intervertebral space, but it also causes a reduction in the size of the foramen of exit.

Because of these considerations and because the back symptoms often arise from a combination of

other factors, Magnuson opposes operation for a ruptured disc without definite evidence of root pressure, unless every other method of treatment has failed. If a ruptured disc is operated upon, the spine should be permanently immobilized to provide continued relief by removing strain from the degenerated tissues.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

STUDIES ON THE EFFECTS OF POSTURE IN SHOCK AND INJURY. George W. Duncan, Stanley J. Sarnoff, and C. Martin Rhode. *Annals of Surgery*, CXX, 24, July 1944.

This is a report on an intensive study of the effects of posture in shock. Thirty patients, in various degrees of shock derived from several causes, were divided into two groups. Group 1 included sixteen patients with greater degrees of shock, injury, and hemorrhage. Group 2 consisted of fourteen patients in whom both the injuries and the blood loss were less.

Determination of plasma volume and hematocrit values were made before the postural alterations were begun. Subsequently these determinations were made both during the study and at the end. Three readings at two-minute intervals were made of the blood pressure and the pulse rate, and then the patient was placed in the foot-up position, by elevating the foot of the bed on twelve-inch blocks. Because of the rapidity of the changes which followed this postural alteration, observations were made on blood pressure, the pulse rate, and other signs and symptoms at one, three, and five-minute intervals. The patient was then returned to the horizontal position, and the observations were repeated. Then the same procedure was carried out with the patient in the head-up position.

The results show the importance of posture in the treatment of both severe and mild injuries. In the patients in Group 1, the foot-up position produced improvement in the physical signs. On the other hand, patients with less severe injuries showed little response to the foot-up position. However, the great importance of posture was shown by the dramatic changes produced in mildly injured persons, when they were placed in the head-up posture; in this position they promptly showed signs of collapse. The severely injured patients apparently were less affected by the head-up position.

This report is the first experimental evidence of the relative effects of posture in injured patients. The so-called shock position had previously been recommended on the basis of animal experiments or on the observations of normal persons. It is helpful to have these matters so well clarified, and it is of great importance to know that the head-up posture is so harmful even in mild injuries.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

NON-ARTICULAR SYPHILITIC ARTHRITIS. P. S. Gupte. *The Antiseptic*, XLI, 180, March 1944.

The author reports three cases of supposed syphilitic arthritis of the wrist, hip, and knee, respectively. The report, however, is not convincing, since no laboratory evidence of syphilis is presented, and the presumptive diagnosis is apparently based solely on the therapeutic test of improvement and relief of symptoms under treatment with neoarsphenamine.—*Robert M. Green, M.D., Boston, Massachusetts.*

SURGICAL EXPERIENCES IN THE MIDDLE EAST (1941 TO JULY 1942). St. J. D. Buxton. *The British Journal of Surgery*, XXXI, 111, 1943.

The general plan of hospital service, transport, and personnel in Libya and Egypt is reviewed. The article is accompanied by excellent photographs.

A study is presented of the clinical work, with special reference to gunshot wounds of bones and joints. Treatment is considered as administered (1) in forward areas, and (2) at the Base.

1. *Treatment in Forward Areas*

Shock treatment, consisting of morphine, fluids, rest, and warmth should be given all patients, whether they show signs of shock or not. Blood transfusions are indicated in certain cases, but blood does not relieve battle or travel fatigue. Antitetanic serum is given all patients. During the period described in this report, sulphanilamide was in use. Prophylactic oral administration of twenty to twenty-five grams was carried out during the first four or five days. In wounds complicated by fracture, it was considered to be of no value after this time, except that five grams were given during the thirty-six hours preceding the change of a plaster.

"There is no place for primary excision and suture of wounds complicated by fracture of a long bone in the Middle East."

The "delayed operation", not carried out early, but before there is gross infection, consists of cleansing the skin, excision of one-eighth to one-quarter of an inch of the skin edges, the removal of all dead or dying tissue, the trimming of muscle, careful hemostasis, dusting the wound with sulphanilamide powder, and packing the wound loosely with vaseline gauze. No manipulation of the bone is done through the wound.

The "late operation", done in the presence of established infection, consists chiefly in the enlargement of the wound, and drainage if necessary.

Splinting should be simple. For the humerus and shoulder a plaster slab six inches wide is applied, so

that it extends from the nape of the neck over the flexed elbow and up to the axilla. This U-shaped plaster is held in place by a few turns of plaster around the arm, and is supported by a wrist sling. Plaster is also used for fractures of the elbow, forearm, and hand, the comfort of the patient being the chief consideration.

A patient with a fracture of the femur or of the knee joint is transported in a Thomas splint and never in a plaster spica. Plaster over the extension bands applied to the skin and then supported by the Thomas splint may be used.

2. *Treatment at the Base*

Factors determining when operation shall be performed are temperature, pain, and the amount of discharge. Operation is often postponed for a week. The plaster cast is removed, and the limb cleaned. The dressing is removed, and the skin around the wound is cleaned. Large foreign bodies must be removed, but no search should be made for smaller ones. Sulphanilamide powder is dusted into the wound and vaseline gauze is packed in lightly. If the wound is infected and the patient has reached the Base eight days after injury, open treatment by packs and irrigation is used, but otherwise a plaster-of-Paris encasement is again applied.

In determining the method of *splinting* to be used, the following points are considered. A type of splinting which can be continued until union occurs should be selected. To secure anatomical alignment, the splint must fix the whole length of the bone, and, in the lower limb, allow for extension with support of the fracture. In grossly comminuted fractures from gunshot injuries, extension should not be used to gain the full length of the limb, as a central abscess with sequestration may be formed.

The author does not advocate the guillotine amputation. He advocates saving skin flaps, if necessary sewing them back away from the wound. "Sites of election do not exist in war surgery." It is a basic principle to save every inch of limb that is possible.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

MILITARY SURGERY IN THE MIDDLE EAST. Arthur E. Porritt. *The British Journal of Surgery*, XXXI, 208, 1944.

Advances in war surgery in the Middle East are at present characterized by:

1. The increased facilities offered by the forward medical units and the development of air transport evacuation;
2. The increased use of blood transfusions;
3. The use of sulphonamides;
4. The extended use of plaster-of-Paris as an immobilizing dressing for wounds of soft tissues as well as fractures;
5. The avoidance of primary suture of wounds, the greater use of secondary suture ten to fourteen days after injury, and the early use of skin-grafting;
6. The cessation of the use of tannic acid for war burns, and the substitution of sulphonamide-oil or sulphonamide-vaseline combinations.

The writer bases his remarks on eighteen months' experience in a "Line of Communication" Desert Hospital in the Middle East. Five thousand battle casualties were received during this time. In respect to orthopaedic cases he has several conclusions:

In the forward area, a broken bone should be considered as incidental in a compound wound. Immobilization of the limb is the only treatment for the fracture at that time. At the Base, the fracture must be reduced by manipulation, open operation, or by skeletal traction; overpull by skeletal traction is to be avoided. The Steinmann pin is preferred to the Kirschner wire for fractures of the femoral shaft.

Every attempt is made to save limbs. There have been but five amputations per 1000 casualties in this Hospital. In doing an amputation, a tourniquet is used distal to the site of amputation, but never on the proximal side. As all battle wounds are potentially septic, no amputation should be done at a site of election. "A guillotine amputation is a surgical crime. But in a primary emergency amputation, the skin flaps must never be sutured. At the most they should be held together with one or two interrupted silkworm gut sutures. It is probably better to leave the flaps wide open or even suture them back to more proximal skin. In many cases secondary suture can be safely and satisfactorily carried out."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

HUMERO-RADIAL SYNOSTOSIS. E. Frankel. *The British Journal of Surgery*, XXXI, 242, 1944.

A review of the literature reveals only twenty-two reports of humeroradial synostosis. The author adds one case.

A male, aged twenty-three, came under observation for severe uraemia from which he died. On antemortem examination, he showed bilateral humeroradial synostosis, with his elbows flexed at slightly less than a right angle. He was one of several children and four of them presented this same condition, although none of their ancestors had shown it. One of twins, but not the other, suffered from the same condition. Several of the children had abnormal patellae.

It seems certain that this was a hereditary condition. In embryos of fourteen and twenty-two milli-

meters, there is no joint space, but it is formed during the third intra-uterine month. In all these patients, the factor responsible for the deformities must have been active during the first three months of foetal life. Chronic renal disease was present in two of the seven children. Four of the children died before the early twenties; none has produced any children.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE. F. Crooks and A. N. Birkett. *The British Journal of Surgery,* XXXI, 252, 1944.

Fifty-nine cases of fracture of the cervical spine are reviewed. These were selected from 618 spine fractures out of a total of 39,479 fractures treated. In industrial fracture work, the incidence of cervical spine injury is one to 600 general fractures. These cases are analyzed with regard to the type of injury, age of the patient, and the frequency of fracture and displacement at the different levels of the neck.

Isolated spinous-process fractures are found in relation to fracture-dislocation of the neck, or as isolated fractures due to muscle or direct violence on the spinous process itself, the latter having been previously described as "clay-shoveller's fracture". If the type of violence causing the accident is that which would have been liable to give rise to fracture-dislocation of the spine, then fracture of a spinous process must be regarded as evidence that some degree of fracture-dislocation has occurred. The clay-shoveller's type of fracture is a comparatively innocent lesion.

Emphasis is laid on fractures of the upper cervical spine and on the specialized anatomy of the axis as a factor in the causation.

In cases of fracture-dislocation, complete replacement is not necessary for a good functional recovery, but every effort should be made to secure and maintain a complete reduction.

In patients with chronic arthritis, injury to the lower cervical spine may result in injury to the cord. —*Ernest M. Daland, M.D., Boston, Massachusetts.*

CONGENITAL DISLOCATION OF THE SHOULDER. Geoffrey Flavell. *The British Journal of Surgery,* XXXI, 272, 1944.

Twenty examples of congenital dislocation of the shoulder have been reported in the literature, and of these seven were bilateral. The author presents another case of bilateral dislocation. This was in a boy of eleven who had no symptoms, but who was unable to bowl at cricket. The muscles of the shoulder girdle were wasted, but there was no paralysis. There was complete absence of the glenoid cavities, but no flattening of the humeral heads. The boy could clasp his hands behind his back, and could bring them up over his head to the front without unclasping them. Inasmuch as he had a full range of motion without pain, no operation was done; but he was given exercises and electrical stimulation.

Treatment of reported cases has varied, and has included manipulation and plaster, resection of the head of the humerus, the Nicola operation, and reefing of the capsule.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

STABILIZATION OPERATIONS OF THE FOOT. A. K. Basu. *Calcutta Medical Journal,* XXXIX, 9, 1942.

The author describes and summarizes six types of operation for stabilization of the foot to produce a firm, painless foot, suitable for weight-bearing and progression. Indications for their employment are in postparalytic flail-foot, in neglected congenital talipes, in peroneal-nerve injuries, and in fractures of the talus or calcaneum. The operations described are Whitman's astragalectomy, Naughton Dunn's triple arthrodesis, Lambrinudi's operation, subastragalar arthrodesis, Campbell's operation for paralytic foot-drop, and Putti's operation for paralytic calcaneal deformities. The author reports five cases in which he has used one or another of these techniques, and discusses postoperative treatment and comparative results. —*Robert M. Green, M.D., Boston, Massachusetts.*

TWO CASES OF FIBROUS DYSPLASIA OF BONE. H. A. Brown. *Clinical Proceedings. The Journal of the Cape Town Post-Graduate Medical Association,* II, 157, 1943.

Two cases of fibrous dysplasia of bone, both unilateral, are reported. In the first patient, a girl, twenty-one years of age, the bones of the left side were affected. Two exostoses were found on the skull, on the ventral and occipital regions, respectively. The skull changes were suggestive of leontiasis ossea, with sclerotic changes at the base and frontal regions. The long bones of the left side showed thinning of the overlying cortex, but no general decalcification. The only biochemical change was a raised phosphatase during the active phase,—twelve Bodansky units.

In the second patient, a girl, nineteen years of age, the right side of the body was involved. Areas of rarefaction, with expansion of the overlying cortex and no generalized decalcification, were seen in the metaphyseal regions of the right femur and right tibia. This patient suffered a pathological fracture of the right tibia. The skull showed areas of rarefaction which were bilateral.

The author's diagnosis in both cases was that of fibrous dysplasia of bone.

FRACTURE OF FEMORAL NECK AND TROCHANTER. Lawson Thornton. *The Journal of the Medical Association of Georgia*, XXXIII, 136, 1944.

In 1935, the author devised a method of attaching a Lane plate to the end of a Smith-Petersen nail for internal fixation of trochanteric and subtrochanteric fractures, and has employed the device routinely in all trochanteric fractures. For non-union of fracture of the femoral neck in old people, the Schanz osteotomy, plus internal fixation with a nail-plate, is the operation of choice. In those cases where non-union seems to be inevitable, small peglike grafts, three-sixteenths of an inch in diameter, may be placed parallel to the Smith-Petersen nail to increase the chances of union.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE TREATMENT OF DEEP BURNS AND CONTRACTURES. J. H. Kite. *The Journal of the Medical Association of Georgia*, XXXIII, 139, 1944.

This report considers patients who have survived the initial shock of severe burns. All such patients should be hospitalized. The burned area should be protected from infection by adherence to strict surgical technique. Saline or boric-acid dressings are preferred to tannic acid for deep burns. (Central necrosis of the liver may follow the use of tannic acid in burns. This destruction of the liver is seen only in the patient treated with tannic acid, and is quite different from that caused by the toxaemia of burns and scalds. The eschar of tannic acid may, in addition, cause severe contracture of tissues and cut off circulation.) Immediate application of vaseline gauze and a pressure dressing, left on for two weeks, is advocated by Allen and Koch. One of the chief errors in treating burns is to wait too long to apply skin grafts. If the flexor surface of a joint is involved, this area should be grafted at the earliest possible moment; this will prevent contractures. Davis's "small deep grafts" are preferred. They may be applied under a local anaesthetic. Often it is necessary to apply a split-thickness or whole-thickness graft over joints to prevent contractures. For this purpose the Padgett dermatome is recommended.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE USE OF SULPHONAMIDES FOR SUPPRESSION OF BACTERIAL GROWTH IN STORED BLOOD. H. L. Jensen. *The Medical Journal of Australia*, II, 376, 1943.

Since certain bacteria are capable of rapid growth at 5 degrees centigrade, the temperature at which blood is stored, the need of a bacteriostatic or even bactericidal agent is obvious. By controlled experiments, the author has found that mercurial antiseptics are of little value. Of the sulfonamides, sodium sulfathiazole added to measured amounts of stored blood, in concentrations of 0.2, 0.1, and 0.05 per cent., was seen to be most effective. However, if this procedure is to be adopted, the lowest possible concentrations of sulfonamides should be used to avoid dangers to recipients already under sulfonamide therapy.

It must be said that some psychrophilic, sulfonamide-tolerant organisms do occur, as well as sulfonamide-resistant fungi, making strict aseptic care essential in the collection of blood to be stored.

DYSENTERIC ARTHRITIS: CASE REPORTS AND COMMENTS. N. J. Bonnin and H. B. Kay. *The Medical Journal of Australia*, II, 380, 1943.

Dysenteric arthritis has been traced by the authors in several patients, apparently presenting only surgical symptoms. Aching pain in the knee joint following trauma was most common. Joint temperature was high, with effusion present; acute local tenderness and severe pain on movement were strikingly absent.

Local treatment to the joint proved to be ineffective. Sigmoidoscopic examination revealed the presence of bacterium dysenteriae Flexner, where cultural examination of the stool had been negative. In every patient, there was a history of mild diarrhoea, occurring a few months before trauma to the knee joint had taken place.

Treatment included sodium-sulphate therapy, with a restricted diet. Where this failed, 120 grams of sulfaguanidine was given, and, in stubborn cases, local irrigation of the bowel was resorted to.

The condition of the affected joint was seen to improve only after sigmoidoscopic examination gave a negative result. One patient was cured by sodium-sulphate therapy; others required sulfaguanidine; and one, local irrigation.

OBLIQUE FRACTURES OF BOTH BONES OF LOWER LEG. Louis H. Edmunds. *Northwest Medicine*, XLIII, 227, 1944.

The oblique fracture is always difficult to immobilize and keep in good alignment, with the fractured surfaces in accurate apposition. It may be treated successfully by internal fixation with 20-gauge stainless-steel wire, using two or three loops around the entire bone. This firmly approximates the fractured surfaces. Such secure fixation will ensure more rapid healing, and will guard against a tendency toward late displacement with resultant delayed or non-union. Early weight-bearing is permitted and the period of disability reduced.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

DIAGNOSIS AND TREATMENT OF OSTEOCLASTOMA. James F. Brailsford. *Radiology*, XLIII, 35, 1944.

Osteoclastoma, known also as myeloid sarcoma, myeloma, and giant-cell sarcoma, shows a typical roentgenographic appearance, and is located usually in the extremity of a bone of a young adult, more commonly in the lower end of the radius, the femur, or the tibia, or the upper end of the tibia. The tumor slowly dissolves the bone; it does not infiltrate as sarcoma does; the adjacent bone retains its normal character, and its borders show no increased density indicating reaction.

As the tumor grows, the surrounding bony wall thins, and finally bulges. At this stage, but not before, a periosteal reaction—a thin periosteal accretion of new bone—may appear. Ultimately, the bony wall may be completely absorbed. The subarticular bone is more resistant, and the articular cartilage usually remains intact.

Differentiation must be made from multilocular cyst, osteitis fibrosa cystica, chondroma, single polyostotic fibrous dysplasia, solitary myeloma, certain sarcomata, secondary carcinoma, and tuberculosis.

The author opposes biopsy on the ground that it merely confirms the roentgenographic evidence; that it weakens the bone and "removes the scaffolding on which repair can be built up"; that it fails to show whether or not the tumor will metastasize; that it may actually disseminate the tumor cells; and that the surgical trauma may incite malignant metaplasia in some cases. Evacuation of the tumor cells from the bone, followed by carbolization of the walls, has not always prevented recurrence of the tumor and later metastasis, and it does impair seriously the stability of the bone.

Roentgenotherapy at first results in an apparent extension of the tumor, but after several months a progressive reossification of the tumor site will occur. The added osteolysis from irradiation necessitates immobilization of the tumor site until reossification has taken place, to protect the limb against fracture. Radiation is indicated even though amputation may later be necessary, and the author feels that biopsy is contra-indicated.—*Edward N. Reed, M.D., Santa Monica, California.*

ACCIDENTAL TRAUMA AND TUMOR METASTASIS. Benedict J. Toth. *Radiology*, XLII, 579, 1944.

Two cases are presented in which there appeared to be definite relationship between accidental trauma and the subsequent localization at the site of the trauma of metastasis from pre-existing malignant neoplasms.

In one case, the primary lesion was a bronchiogenic carcinoma of the lung, and in the other a carcinoma of the stomach. The first patient suffered severe injuries to the right wrist and forearm, including a comminuted fracture of the radius an inch above the lower articular surface. This united, in good position, but progressively more severe pain developed in the wrist, with a soft-tissue swelling along the radial aspect, and marked osteoporosis.

Exuberant callus developed, and later the soft-tissue mass surrounded the fracture site. Except for periostitis and osteoporosis, no bony changes were demonstrable. At operation, a non-infiltrating circumscribed mass, loosely attached to the bone, was enucleated. It was found to be metastatic adenocarcinoma. A number of other metastatic nodules appeared in various locations. One, over the anterior aspect of the left leg, was believed by the patient to be the result of a slight bump several weeks earlier.

To help clarify the relationship between trauma and the development of the metastasis, an artificial trauma of the front of the right leg was produced by repeated blows with the wooden handle of a hammer. A hematoma was produced, but at postmortem examination, more than two months later, no evidence of tumor at this site was found.

The second patient suffered a compression fracture of the first lumbar vertebra, and abrasion of the scalp. He had a small palpable mass in the epigastrium. Progressive pain in the lower back and ribs developed. A destructive lesion of the eleventh rib was discovered. Numerous nodular tumors developed in the thoracic wall and elsewhere. Death occurred three months following the accident. At autopsy, a fungating carcinoma of the stomach was found, with many metastases affecting six ribs, both clavicles, the sternum, and the sixth and seventh thoracic vertebrae; but there was no evidence of tumor cells in the fractured first lumbar vertebra.

The seven postulates, set up by Segond and Thiem, Lubarsch, and Ewing as requirements to be fulfilled in the establishment of such causative relationship, were applied. It was found, in Case 1, that, while the metastatic tumor was located at the site of the fracture of the radius, it arose in the soft tissues, with gradual involvement of the bone over a large area, after the soft-tissue mass had reached considerable proportions. The same picture developed in the other metastases overlying bone.

In both cases, one or more of the seven postulates failed of fulfillment. These findings are in agreement with those of other investigators of the same problem. The author concludes that there is little evidence of any connection between trauma and the location of metastases from malignant tumor.—*Edward N. Reed, M.D., Santa Monica, California.*

LA ESPONDILITIS BRUCELOSICA (Brucella Melitensis Spondylitis). S. Di Rienzo. *Revista Argentino-Norteamericana de Ciencias Médicas*, I, 737, 1944.

The author presents an extremely well-illustrated and interesting article on spondylitis due to bru-

cella melitensis. The spine appears to be a site of special localization in brucellosis. Statistics of different authors indicate that as few as 20 per cent., and as many as 75 per cent., affected may manifest signs of spondylitis.

Among the cases of spondylitis, 80 per cent. occur by preference in the lumbar area. It is not known whether the disease begins in the vertebral cartilage or in the body itself. It differs from tuberculous spondylitis in that almost invariably *multiple vertebrae, each in a different phase of the disease,* appear to be involved.

The likelihood of vertebral involvement may be suspected, when, in the course of the disease, *lumbar* pain and *spasm* appear. The pain may be severe or mild, but it differs from the pain seen in Pott's disease in that it is not relieved by rest or immobilization. The pain is made worse by motion, pressure, or percussion over the affected area. The pain may radiate down either extremity, to the hip joint, or around the abdomen. When the infection in the vertebra leads to prevertebral abscess formation, a peritoneal reaction with rigidity of the abdominal wall or ileus may lead to surgical intervention, unless a correct diagnosis is made.

Roentgenographically, the disease may be divided into three main phases: (1) the stage of onset, (2) the florid stage, and (3) the stage of healing.

In the first and second stages, the disease will be localized by preference in (1) the vertebral body, (2) the junction of the body and disc, (3) the junction of body and ligaments, and (4) the sacro-iliac joint. The disease does not seem to involve the small joints, or the transverse or spinous processes of the vertebrae.

In the *acute* phase of the disease, the vertebral body presents a clouded appearance in contrast to the chronic phase in which there is marked prominence of the bony trabeculae. The earliest manifestations of involvement of the vertebral body are seen either at the junction of the upper or lower epiphyseal plates with the anterior ligament, or in the center of the upper or lower plates. Involvement of these plates leads to projections of the nucleus pulposus into the body of the vertebra. If the disc itself is involved, complete destruction of the disc may occur. In the florid stage, the degree of destruction of the body may be variable.

In the reparative phase, calcification (osteophyte formation) is the characteristic phenomenon. Indeed it is particularly in the greater tendency toward calcification and bony condensation that the reaction of the bone to brucella differs from its reaction to tuberculosis.

Diagnosis is made by study of the clinical picture, serological tests, and the roentgenogram. Prognosis depends upon the extent of the lesion. Treatment consists in the use of the specific vaccine.—*Henry Milch, M.D., New York, N. Y.*

ARTRODESIS DOBLE DE LA RODILLA PARA PERMITIR LA MARCHA ERECTA. UNA TÉCNICA UTILIZADA. (Bilateral Arthrodesis of the Knee to Permit Erect Gait.) Eduardo Alcívar Elizalde. *Revista Argentino-Norteamericana de Ciencias Médicas,* I, 815, 1944.

The author reports the case of an adult male, forty-three years old, who had right-angled flexion contractures of both knees, due to Little's disease. The patient was a shoemaker by trade, and was able to get about only with the aid of short crutches.

To correct flexion of the hip and knee, the author first tenotomized the tensor fasciae femoris and then the hamstring muscles of the right leg. Thereafter, resection of the knee joint was carried out. Three months later, a similar procedure was undertaken upon the left leg.

Seven months after the first operation, the patient was permitted up and about with the aid of crutches. At the end of four months, after the second operation, he walked with the aid of a cane, and at the end of two years he walked without any assistance. The right knee is ankylosed in complete extension, the left in 10 degrees of flexion. Although the gait is characteristic, the patient is even able to ascend the stairs.

Photographs illustrate the patient's condition before and after the operations. No mention is made as to the patient's ability to carry on his trade as a shoemaker.—*Henry Milch, M.D., New York, N. Y.*

MORTON'S METATARSALGIA. LOCALIZED DEGENERATIVE FIBROSIS WITH NEUROMATOUS PROLIFERATION OF THE FOURTH PLANTAR NERVE. Lenox D. Baker and Harold H. Kuhn. *Southern Medical Journal,* XXXVII, 123, 1944.

This is a report of fourteen patients with metatarsalgia. All were operated upon for removal of a unilateral or bilateral tumor of the fourth plantar digital nerve. The tumor lies in the webbed space between the third and fourth toes; it is usually unilateral; and is more frequent in women than in men (in this series, ten women, one man). An area of exquisite tenderness is present. The tumor is removed through a dorsal incision between the third and fourth metatarsal heads. Excision of the tumor relieves the pain. No patient has complained of loss of sensation in the toes after resection of the nerve. The size of the tumor or the pathological picture cannot be correlated with the duration or the severity of the symptoms. The largest tumor was removed from the foot of a patient who had had symptoms for only ten months.

The etiology of the lesion is questionable, but the anatomical relationships of the nerve and the pathological findings indicate that it is a degenerative fibrosis of the nerve, with neuromatous proliferation, resulting from, or irritated by, repeated traumata.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

A Method for Fusion of the Wrist. Paul C. Colonna. *Southern Medical Journal*, XXXVII, 195, 1944.

Indications for fusion of the wrist include: chronic inflammatory lesions involving the wrist joint, tuberculous or non-tuberculous, that have caused the wrist to assume a flexed attitude; spastic paralysis with marked flexion deformity of the wrist; conditions following infantile paralysis in selected cases; and severe traumatic arthritis. In some instances muscle transplantation of the flexor muscles of the wrist into the extensors may be desirable preceding fusion. The operation is not done generally before epiphyseal closure is shown by roentgenogram, at sixteen to eighteen years of age. If fusion becomes necessary before this age period, operative closure can be effected.

At operation, the dorsum of the lower end of the radius, the carpal bones, and the proximal third of the second and third metacarpal bones are exposed. A bed is prepared for a rib graft by making clefts in the bases of the second and third metacarpals, and in the lower end of the radius. The graft is removed, with oblique cuts, from the lateral chest wall, on the same side as the wrist to be fused. The natural curve of the rib, when the graft is firmly embedded in its prepared bed, usually gives the desired degree of cocked-up position to the wrist. The graft is split longitudinally with an osteotome and one half is fitted, marrow side down, into the denuded bed in the wrist joint. The other half is sometimes used for chips, to be packed in around the graft.

A circular plaster holds the wrist and arm in position, and bony union can be demonstrated at eight to ten weeks. Support in the cocked-up attitude is continued for at least sixteen weeks following operation. The patient is ambulatory after the first week.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Some Problems of Injured Ankles with Negative X-Ray Findings. Ralph G. Carothers. *Southern Medical Journal*, XXXVII, 266, 1944.

Some ankle injuries are far from "trivial". Treatment cannot be limited to an injection of novocain. In a serious sprain, ligamentous fibers may be torn, and the ankle actually dislocated. The dislocation may reduce itself, and the ankle may exhibit no injury when a roentgenogram is taken. When important ligaments are torn, specifically the talofibular or tibiofibular ligaments, a serious lesion has taken place and a plaster cast, with a walking iron, is the best treatment.

Novocain is injected into the painful area, the foot is supinated as far as possible, and a roentgenogram is taken. If the talus becomes rotated, a serious tearing of the talofibular ligament generally is indicated, and a cast is necessary. (The author demonstrated on cadavera that, although cutting of the external lateral ligaments would not allow the talus to rotate, cutting of the talofibular ligament did.) The cast is left on for two weeks. If the talus does not rotate, strapping is sufficient. Plaster casts should not be used for simple sprains.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Observations on Battle Fractures of the Extremities. Oscar P. Hampton and Joe M. Parker. *Surgery*, XV, 869, June 1944.

This report covers a study of definitive care for approximately 1,400 men with fractures of the extremities due to high-explosive or bullet wounds. Treatment was rendered in a general hospital, which was functioning actively in a zone of communications at a base for a period of eight months. Approximately 98 per cent. of the injuries were given first aid and definitive treatment in forward evacuation or surgical hospitals. For the most part, the initial care was considered to be good. Sulfanilamide had been used in most instances, either in the wound or orally, or both; within an average of eight hours, 92 per cent. of a group of 500 had this prophylactic therapy. In 1,400 cases of compound fractures secondary to high-explosive or bullet wounds, débridement was sufficiently good in the forward medical installations to prevent sepsis in all but fifteen to eighteen cases.

The authors have recommended the filling of the initial compound wound loosely with petroleum-jelly gauze. They have strongly and wisely advised against tight *packing* of the wound.

Primary internal fixation in compound fractures caused by high explosives is considered unwise, and will fail in most instances. Pins for skeletal traction or for plaster fixation, which were inserted before the patient reached the base hospital, produced a high incidence of complications. Padded casts were found to be more satisfactory than primary skin-tight plaster.

The authors are enthusiastic about the method of cast traction in the prevention of deformity and osteomyelitis in compound fractures of the tibia and fibula.—*Edward L. Compere, M.D., Chicago, Illinois.*

Fractures of the Femur. Results of Treatment over a Period of Six Years at The Mayo Clinic Ralph K. Ghormley, George S. Phalen, Robert E. VanDemark, and Clarence A. Luckey. *Surgery*, XV 887, June 1944.

This paper represents a study of the results of treatment of fractures of the femur over a period of six years at The Mayo Clinic. During this period, 103 patients were admitted with fresh fractures of the shaft

of the femur. Fourteen of these patients had fractures of both femora. During this same period, sixty-one patients, who had old fractures of the femoral shaft, were treated; and thirty-three pathological fractures of the femoral shaft were observed. No follow-up study of these different groups was made.

Different methods of treatment were used, since several surgeons were responsible for the treatment of fractures. There were five deaths in the cases in which closed reduction was employed. Union occurred within three months in fifty (58.8 per cent.) of the femora in which treatment was by closed reduction. Bony union was present, within three months of operation, in only eleven (34.4 per cent.) of the femora where open reduction was resorted to, in instances in which closed reduction did not seem to promise a satisfactory end result, or where it had been tried and failed.

In many cases, the period of hospitalization was shortened by the use of open reduction with internal fixation. In the entire study, good end results were obtained in 81.2 per cent. of the cases.—*Edward L. Compere, M.D., Chicago, Illinois.*

Traumatic Synostosis of the Distal Third of the Radius and Ulna. Floyd Hurt and Spencer C. Flo. *Surgery*, XV, 894, June 1944.

In the experience of the authors, and as evidenced by a review of the literature, traumatic synostosis of the shaft of the radius and ulna is of rare occurrence.

A soldier, twenty-seven years old, came to the Station Hospital, complaining of a painful left forearm. He gave a history of having been struck by a hammer across the forearm in 1934, and was told that the arm was broken at that time. Examination at the Station Hospital showed the forearm to be fixed in mid-pronation; rotation was impossible. A bony formation could be felt on the flexor surface of the forearm about six centimeters proximal to the wrist joint. Roentgenograms revealed a heavy bridge of bone between the radius and the ulna, in the lower third of the forearm. This bony bridge was excised; the operation resulted in clinical improvement, with absorption rather than regeneration of bone in this area.—*Edward L. Compere, M.D., Chicago, Illinois.*

Strain of Right Rectus Muscle Simulating Acute Appendicitis. E. Dean Babbage, C. W. McLaughlin, Jr., and R. L. Fruin. *War Medicine*, V, 280, May 1944.

Various conditions affecting the musculature or the skeletal structures of the body may produce visceral symptoms. A most careful examination may be required in order that the correct diagnosis can be made. The particular syndrome of pain in the lower abdominal quadrant, produced by strain of the rectus muscles, has rarely been recognized in civilian practice.

The authors of this article have emphasized the difficulty of differentiating between a strain of the right rectus and acute appendicitis. The problem is made more acute by the fact that both conditions usually occur in young and active individuals. They have reported a series of 141 patients with strain of the rectus abdominis. The cases were collected, over a period of approximately nine months, in a large naval training station. Injection of a 1 per cent. solution of procaine hydrochloride into the right rectus was suggested for all patients in whom acute appendicitis could not be excluded by the history or by clinical examination.

The procaine solution relieved the pain, if the primary pathology was in the abdominal wall, but failed to do so in acute appendicitis. Rest in bed proved to be the only satisfactory treatment for the patients with strain of the rectus muscles; the average stay in the Hospital was five and eight-tenths days.

Hematomata of the right rectus abdominis muscle were common in the series, but aspiration failed to withdraw more than one or two cubic centimeters of blood. The condition required at least two weeks of rest in bed in the Hospital for clinical recovery, and absorption of the hematoma required many weeks, after the patient had been discharged.—*Edward L. Compere, M.D., Chicago, Illinois.*

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Appliance for Use in the Conservative Treatment of Collum Fractures of the Mandible, in Maintaining Vertical Dimension of the Jaw and Overcoming Spasm of the Levator Muscles of the Mandible, An. Loren W. Gruber and John Lyford, III. *Am. J. Orthodon. and Oral Surg. (Oral Surg. Sect.), XXIX, 160, 1943* 211

Artrodesis Doble de la Rodilla para Permitir la Marcha Erecta. Una Técnica Utilizada. (Bilateral Arthrodesis of the Knee to Permit Erect Gait.) Eduardo Alcívar Elizalde. *Revista Argentino-Norteamericana de Ciencias Méd., I, 815, 1944* 854

Association of Thrombophlebitis with Hematogenous Bone Infection, The. Abraham O. Wilensky. *Surgery, XV, 653, 1944* 619

Causes of Pain in Feet after Prolonged Immersion in Cold Water. James C. White and Shields Warren. *War Med., V, 6, 1944* 434

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Combined Anterior and Posterior Spina Bifida in a Living Neonatal Human Female. R. L. deC. H. Saunders. *Anat. Record, LXXXVII, 255, 1943* 424

Concept of Muscle Dysfunction in Poliomyelitis. Based on Electromyographic Studies. Arthur L. Watkins, Mary A. B. Brazier, and Robert S. Schwab. *J. Am. Med. Assn., CXXIII, 188, 1943* 221

Congenital Dislocation of the Shoulder. Geoffrey Flavell. *British J. Surg., XXXI, 272, 1944* 851

Consideraciones sobre las fracturas llamadas "patológicas" (Considerations Regarding So-Called Pathological Fractures). Hebert Cagnoli. *Bol. de la Soc. de Cir. de Rosario, X, 3, 1943* 215

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Costilla cervical supernumeraria (Supernumerary Cervical Rib). Pedro Antonio Landa y Carlos A. Botto. *Revista de Med. y Ciencias Afines, V, 494, 1943* 617

Coxa Anteverta Versus Anteversion of the Femoral Neck. Henry Milch. *Bull. Hosp. Joint Diseases, IV, 79, 1943* 427

Dental Findings in Four Cases of Cleidocranial Dysostosis. Jerry A. Millhon and Louie T. Austin. *Am. J. Orthodon. and Oral Surg. (Oral Surg. Sect.), XXX, 30, 1944* 613

Diagnosis and Treatment of Osteoclastoma. James F. Brailsford. *Radiology, XLIII, 35, 1944* 853

Differential Diagnosis of Causes of Pain in the Lower Back Accompanied by Sciatic Pain. Paul B. Magnuson. *Ann. Surg., CXIX, 878, 1944* 848

Dislocation of the Proximal End of the Fibula. Case Report. Samuel R. Terhune, Samuel B. Thompson, and Thomas S. Eddleman. *Southern Med. J., XXXVI, 271, 1943* 226

Division of the Flexor Tendons within the Digital Sheath. Sumner L. Koch. *Surg. Gynec. Obstet., LXXVIII, 9, 1944* 433

Dysenteric Arthritis: Case Reports and Comments. N. J. Bonnin and H. B. Kay. *Med. J. Australia, II, 380, 1943* 852

Effect of Infrared Heat on Localized Poliomyelitis and Neuritis. John A. Toomey. *J. Pediat., XXII, 135, 1943* 222

Effect of Irradiation upon the Composition and Vascularity of Growing Rat Bones, The. Charles L. Hinkel. *Am. J. Roentgenol., L, 516, 1943* 212

Embryonal Carcinoma Primary in the Mandible of a Child with Involvement of Tooth Pulp. Charles M. Campelia and Paul E. Boyle. *Am. J. Orthodon. and Oral Surg. (Oral Surg. Sect.), XXIX, 299, 1943* 211

Enfermedad de Koehler-Pellegrini-Stieda (Köhler-Pellegrini-Stieda Disease). Luis Peralta. *In* Libro de Oro. Dedicado al Professor Dr. Alberto Baraldi, 1915–1940. (Golden Book. Dedicated to Prof. Dr. Alberto Baraldi on the Twenty-Fifth Anniversary of His Surgical Career.) Rosario, Argentina, Emilio Fenner, 1940 421

Eosinophilic Granuloma with Report of One Case Involving First the Mandible, Later Other Bones, and Being Accompanied by Diabetes Insipidus. Kurt H. Thoma. *Am. J. Orthodon. and Oral Surg. (Oral Surg. Sect.), XXIX, 641, 1943* 613

Estudio crítico sobre el tratamiento de la Osteomelitis Hematógena. Revision de 300 casos. (Critical Study of the Treatment of Hematogenous Osteomyelitis. Review of 300 Cases.) Isidoro Pascau Pérez. *Cir. Ortop. y Traumatol., X, 81, 1943* 219

Evaluation of Disability in Low Back Injuries. Forrest L. Schumacher. *Radiology, XLI, 18, 1943* 224

"Exhaustion" Fracture of the Spine. Preliminary Report on One Case. J. Blair Hartley. *British J. Radiol., XVI, 348, 1943* 218

Fixação do condilo externo do úmero com o fio de Kirschner (Fixation of the External Humeral Condyle with a Kirschner Wire). Bruno Maia. *Bol. do Instituto de Assistencia Hospitalar, III, 25, 1942* 426

Fracturas expuestas (Compound Fractures). Juan B. Carpanelli. *Revista de Med. y Ciencias Afines, V, 6, 1943* 226

Fractura-luxación de la Articulación de Lisfranc (Fracture-Dislocation at Lisfranc's Articulation). Luis A. Introini. *In* Libro de Oro. Dedicado al Professor Dr. Alberto Baraldi, 1915–1940. (The Golden Book. Dedicated to Prof. Dr. Alberto Baraldi on the Twenty-Fifth Anniversary of His Surgical Career.) Rosario, Argentina, Emilio Fenner, 1940 421

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Fractures about the Ankle. J. S. Batchelor. *Med. Press and Cir., CCX, 138, 1943* 222

Fractures and Dislocations of the Cervical Spine. F. Crooks and A. N. Birkett. *British J. Surg., XXXI, 252, 1944* 851

Fracture of Femoral Neck and Trochanter. Lawson Thornton. *J. Med. Assn. Georgia, XXXIII, 136, 1944* 852

Fractures of the Femur. Results of Treatment over a Period of Six Years at The Mayo Clinic. Ralph K. Ghormley, George S. Phalen, Robert E. VanDemark, and Clarence A. Luckey. *Surgery, XV, 887, 1944* 855

Fractures of the Femur in War-Time: A Review of Thirty-Two Cases. B. T. Keon-Cohen. *Australian and New Zealand J. Surg., XII, 163, 1943* 214

Fractures of the Neck of the Femur. An Analysis of 157 Intracapsular and Extracapsular Fractures. Irwin E. Siris and John D. Ryan. *Surg. Gynec. Obstet., LXXVIII, 631, 1944* 620

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Hemangioma of Vertebra with Compression of Cord. Report of a Case Cured with Radiation Fourteen Years Ago. L. Minor Blackford. *J. Am. Med. Assn., CXXIII, 144, 1943* 221

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Hydatid Disease (Echinococcosis) Mainly from the Clinical Standpoint. I, II. Louis Barnett. *Med. Press and Cir., I, 8 and 26, 1944* 615

Ice Skater's Fractures: A Form of Fatigue Fracture. C. F. Ingersoll. *Am. J. Roentgenol., L, 469, 1943* 212

Infected Burns and Surface Wounds. The Value of Penicillin. D. C. Bodenham. *Lancet, II, 725, 1943* 429

Internal Derangements of the Knee Joint in the Canadian Army (Overseas). D. W. MacKenzie and J. A. MacFarlane. *Canadian Med. Assn. J., XLIX, 472, 1943* 219

Internal Fixation of Fractures of the Patella with Cotton Suture Material. Lyon K. Loomis. *Surgery, XV, 602, 1944* 619

La Espondilitis Brucelosica (Brucella Melitensis Spondylitis). S. Di Rienzo. *Revista Argentino-Norte-americana de Ciencias Méd., I, 737, 1944* 853

Las periartritis osificantes del codo (Ossifying Periarthritis of the Elbow). Oscar R. Maróttoli y Arnoldo E. Didier. *Anal. de Cir., VIII, 321, 1942* 213

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Luxación interfalángica recidivante. Tratamiento. (Recurrent Interphalangeal Dislocation. Treatment.) R. García Capurro y J. C. Russi. *Bol. de la Soc. de Cir. del Uruguay, XIV, 36, 1943* 217

Luxación recidivante del hombre. Curación. (Recurring Luxation of the Shoulder. Cure.) Alberto Rodriguez Egana y José Ernesto Rodrigues. *Revista de Méd. y Ciencias Afines, V, 89, 1943* 226

Medical Treatment of Hematogenous Osteomyelitis, The. D. E. Robertson. *Ann. Surg., CXVIII, 318, 1943* 213

Metastatic Neuroblastoma in Bone. S. Graham Aitken. *New Zealand Med. J., XLI, 209, 1942* 223

Method for Fusion of the Wrist, A. Paul C. Colonna. *Southern Med. J., XXXVII, 195, 1944* 855

Military Surgery in the Middle East. Arthur E. Porritt. *British J. Surg., XXXI, 208, 1944* 850

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Multiple Neuritis of the Shoulder Girdle. A Report of Nine Cases Occurring in the Second New Zealand Expeditionary Force in the Middle East. E. D. Burnhard and T. G. Fox. *New Zealand Med. J., XLI, 243, 1942* 223

Multiple Spontaneous Idiopathic Symmetrical Fractures. Milkman's Syndrome. Louis Edeiken and Norman G. Schneeberg. *J. Am. Med. Assn., CXXII, 865, 1943* 220

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Nuestra Conducta en las Fracturas Intracapsulares del Cuello del Fémur (Our Conduct of Intracapsular Fractures of the Neck of the Femur). Juan Farill. *Gac. Med. de México, LXXIII, 185, 1943* 428

Oblique Fractures of Both Bones of Lower Leg. Louis H. Edmunds. *Northwest Med., XLIII, 227, 1944* 852

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Orthopaedic Influence on the Treatment of Fractures. A Clinical Study. G. R. Girdlestone. *Lancet, II, 593, 1943* 429

Orthopedic Problems at a Naval Air Station. E. L. Jewett and Herschel Penn. *Southern Med. J., XXXVI, 533, 1943* 227

Osteoclisis. Nueva técnica para la transfusión de sangre y liquidos. (Osteoclysis. A New Technique for Transfusion of Blood and Fluids.) Guillermo Benavides Uribe. *Revista Mexicana de Cir. Ginec. y Cáncer, XI, 136, 1943* 617

Osteodystrophia Fibrosa Cystica and Juvenile Hyperthyroidism. J. E. Jacobs. *Southern Med. J., XXXVI, 668, 1943* 617

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Panadizos Necrosantes del Pulgar (Necrosing Panaris of the Thumb). Héctor A. Ardao. *Bol. de la Soc. de Cir. del Uruguay, XIII, 45, 1942* 614

Pathogenetical Correlations between Periarteritis Nodosa, Renal Hypertension and Rheumatic Lesions. Hans Selye and E. Irene Pentz. *Canadian Med. Assn. J., XLIX, 264, 1943* 218

Pathology, Clinical Manifestations and Treatment of Lesions of the Intervertebral Disks. Albert Oppenheimer. *New England J. Med., CCXXX, 95, 1944* 430

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Posterior Subastragaloid Arthrodesis in Fractured Os Calcis. J. R. Armstrong. *Lancet, II, 506, 1943* 428

Posttraumatic Ossification of the Thigh. Oscar R. Maróttoli. *Bol. y Trab. de la Soc. Argentina de Cir. Ortop., I, No. 2, 1943* 614

Principles of Treatment in Peripheral Nerve Injuries. Max T. Schnitker. *Northwest Med., XLIII, 5, 1944* 616

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Pyogenic Coxitis. II. Indications for Surgical Treatment in Residual and Chronic Stages and End-Results of Reconstruction in 53 Patients. Paul H. Harmon and Carroll O. Adams. *Surg. Gynec. Obstet., LXXVIII, 497, 1944* 619

Radiation Therapy of Acute Subdeltoid Bursitis. Arthur A. Brewer and Oscar C. Zink. *J. Am. Med. Assn., CXXII, 800, 1943* 220

Refrigeration Anesthesia in Amputations. Harry E. Mock and Harry E. Mock, Jr. *J. Am. Med. Assn., CXXIII, 13, 1943* 221

Repair of the Burned Hand. George Warren Pierce, E. H. Klabunde, and D. Emerson. *Surgery, XV, 153, 1944* 431

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Scar Disabilities of Wounded Hands. B. K. Rank. *Australian and New Zealand J. Surg., XII, 191, 1943.* 214

Similarity of Clinical and Roentgen Findings in Children with Ewing's Sarcoma (Endothelial Myeloma) and Sympathetic Neuroblastoma, The. Robert Phelps Barden. *Am. J. Roentgenol., L, 575, 1943* 424

Sinovitis Seca de los Juntadores de Maiz (Dry Synovitis of Corn Huskers). Fernando Noguerol Armengol. *In* Libro de Oro. Dedicado al Professor Dr. Alberto Baraldi, 1915–1940. (The Golden Book. Dedicated to Prof. Dr. Alberto Baraldi on the Twenty-Fifth Anniversary of His Surgical Career.) Rosario, Argentina, Emilio Fenner, 1940 421

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Some Aspects of the Treatment of War Wounds: A Retrospective and Present-Day Contemplation. A. E. Mortimer Woolf. *Med. Press and Cir., CCX, 207, 1943* 222

Some Problems of Injured Ankles with Negative X-Ray Findings. Ralph G. Carothers. *Southern Med. J., XXXVII, 266, 1944* 855

Spondylolisthesis. Analysis of Fifty-Nine Consecutive Cases. Guy A. Caldwell. *Ann. Surg., CXIX, 485, 1944* 848

Spondylolisthesis: A General Consideration with Emphasis on Radiologic Aspects. A. C. Galluccio. *Radiology, XLII, 143, 1944* 616

Stabilization Operations of the Foot. A. K. Basu. *Calcutta Med. J., XXXIX, 9, 1942* 851

Strain of Right Rectus Muscle Simulating Acute Appendicitis. E. Dean Babbage, C. W. McLaughlin, Jr., and R. L. Fruin. *War Med., V, 280, 1944* 856

"Stress" or "Fatigue" Fractures of Bone. J. Blair Hartley. *British J. Radiol., XVI, 255, 1943* 217

Studies on the Effects of Posture in Shock and Injury. George W. Duncan, Stanley J. Sarnoff, and C. Martin Rhode. *Ann. Surg., CXX, 24, 1944* 849

Studies on Traumatic Shock: I. Blood Volume Changes in Traumatic Shock. Everett Idris Evans, M. J. Hoover, G. Watson James, III, and Theodore Alm. *Ann. Surg., CXIX, 64, 1944* 426

Studies on Traumatic Shock: II. The Restoration of Blood Volume in Traumatic Shock. Everett Idris Evans, G. Watson James, III, and M. J. Hoover. *Surgery, XV, 420, 1944* 618

Sudeck's Acute Bone Atrophy. Report of Case. F. B. Brown. *J. Med. Assn. Georgia, XXXII, 242, 1943* 221

Surgical Experiences in the Middle East (1941 to July 1942). St. J. D. Buxton. *British J. Surg., XXXI, 111, 1943* 849

Synovial Cysts of the Popliteal Space: Clinical Significance and Treatment. G. E. Haggart. *Ann. Surg., CXVIII, 438, 1943* 213

Táctica quirúrgica en los sindromes costoescalénicos (Surgical Policy with the Scalenus Anterior Syndrome). Abel Chifflet y C. Muñoz Monteavaro. *Bol. de la Soc. de Cir. del Uruguay, XIII, 73, 1942* 614

Tarso giboso (Tarsal Gibbus). A. D. Maisonnave. *Bol. de la Soc. de Cir. del Uruguay, XIII, 362, 1942.* 216

Técnica do Professor Godoy Moreira para a osteosintese do colo do femur. Simplificação instrumental. (Prof. Godoy-Moreira's Technique of Osteosynthesis of the Neck of the Femur. Instrument Simplification.) Renan Azzi Leal e Edmundo Batalha. *Revista Brasileira de Ortop. e Traumatol., IV, 55, 1943* .. 617

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Tratamiento quirúrgico de la epifiseólosis clavicular (Surgical Treatment of Clavicular Epiphysiolysis). M. A. Karlen. *Bol. de la Soc. de Cir. del Uruguay, XIV, 94, 1943* 427

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Traumatic Surgery. A Review of Some Bone and Joint Injuries in Wartime. A. G. Ord, Ralph Shackman, and H. L. M. Roualle. *Surgery, XIV, 651, 1943* 228

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Treatment of Bone Cavities, The. Balcombe Quick. *Australian and New Zealand J. Surg., XIII, 3, 1943* 215

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Tumor maligno de extremidad superior de húmero (Malignant Tumor of Upper End of the Humerus). Caubarrere y Rubio. *Bol. de la Soc. de Cir. del Uruguay, XIII, 499, 1942* 216

Two Cases of Fibrous Dysplasia of Bone. H. A. Brown. *Clin. Proc. J. Cape Town Post-Grad. Med. Assn., II, 157, 1943* 851

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Boletín del Colegio Médico de la Habana (Cuba), VII, Núms. 2, 3, 4, 5, 6, 7, y 8, 1944.

Boletines y Trabajos de la Sociedad de Cirugía de Córdoba (Argentina), IV, Nos. 5 y 6, 1943.

Boletines de la Sociedad de Cirugía de Rosario (Argentina), X, Nos. 5–6 y 7–8, 1943; y XI, Nos. 1 y 2, 1944.

Brenthurst Papers. Nos. 3, 4, and 5. Jack Penn, Editor. Johannesburg, South Africa, Brenthurst Red Cross Military Hospital for Plastic Surgery, December 1943, and April and July 1944.

The Bulletin of the U. S. Army Medical Department (Carlisle Barracks, Pennsylvania), Nos. 75, 76, 77, 78, 79, and 80, 1944.

Child Development Abstracts and Bibliography (Washington, D. C.), XVIII, Nos. 1 and 2, 1944.

Cleveland Clinic Quarterly (Ohio), XI, No. 3, 1944.

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Current Medicine (Los Angeles, California), XI, No. 4, 1944.

Hora Medica (Rio de Janeiro, Brasil), Setembro e Outubro, 1943.

Hospital for Joint Diseases (New York, N. Y.). Thirty-Seventh Annual Report, 1943.

Médica (Matanzas, Cuba), II, Núm. 6, 1943; y III, Núms. 2 y 3, 1944.

The Physiotherapy Review (Chicago, Illinois), XXIV, 2, 3, and 4, 1944.

Primera Conferencia Argentina (Buenos Aires), 1943.

Radiography and Clinical Photography (Rochester, New York), XX, No. 1, 1944.

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Revista de Tuberculosis (Habana, Cuba), VII, Núm. 4, 1943.

The Rotarian (Chicago, Illinois), LXV, No. 2, 1944.

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